SIGILL: COLL: HARVARD: CANTAB: NOV: ANGL: 1650.

CHRISTO ET ECCLESIAE

Given to the

BUSSEY INSTITUTION

OF

HARVARD UNIVERSITY.

by

William Everett

15 Feb. 1878.

THE JOURNAL OF THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

VOLUME THE SEVENTEENTH.

PRACTICE WITH SCIENCE.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1856.

THESE EXPERIMENTS, IT IS TRUE, ARE NOT EASY; STILL THEY ARE IN THE POWER OF EVERY THINKING HUSBANDMAN. HE WHO ACCOMPLISHES BUT ONE, OF HOWEVER LIMITED APPLICATION, AND TAKES CARE TO REPORT IT FAITHFULLY, ADVANCES THE SCIENCE, AND, CONSEQUENTLY, THE PRACTICE OF AGRICULTURE, AND ACQUIRES THEREBY A RIGHT TO THE GRATITUDE OF HIS FELLOWS, AND OF THOSE WHO COME AFTER. TO MAKE MANY SUCH IS BEYOND THE POWER OF MOST INDIVIDUALS, AND CANNOT BE EXPECTED. THE FIRST CARE OF ALL SOCIETIES FORMED FOR THE IMPROVEMENT OF OUR SCIENCE SHOULD BE TO PREPARE THE FORMS OF SUCH EXPERIMENTS, AND TO DISTRIBUTE THE EXECUTION OF THESE AMONG THEIR MEMBERS.

Von Thaer. *Principles of Agriculture.*

London: Printed by William Clowes and Sons, Stamford Street, and Charing Cross.

CONTENTS OF VOL. XVII.

APPENDIX.

DIRECTIONS TO THE BINDER.

The Binder is desired to collect together all the Appendix matter, with Roman numeral folios, and place it at the *end* of each volume of the Journal, excepting Titles and Contents, which are in all cases to be placed at the *beginning* of the Volume: the lettering at the back to include a statement of the *year* as well as the *volume*; the first volume belonging to 1839–40, the second to 1841, the third to 1842, the fourth to 1843, and so on.

In Reprints of the Journal all Appendix matter (and in one instance an Article in the body of the Journal), which at the time had become obsolete, were omitted; the Roman numeral folios, however (for convenience of reference), being reprinted without alteration in the Appendix matter retained.

JOURNAL

OF THE

ROYAL AGRICULTURAL SOCIETY

OF ENGLAND.

STATISTICS

OF

THE CORN TRADE,

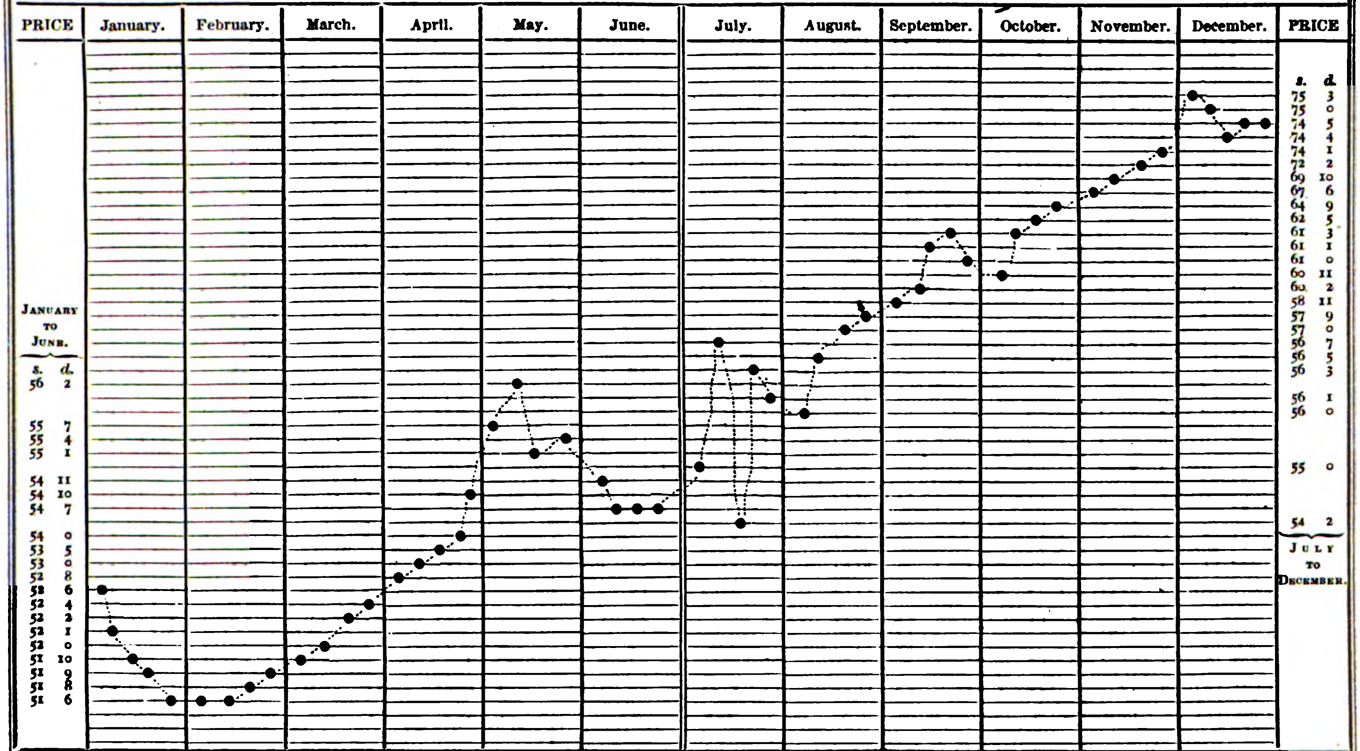
1828-1855.

THE following tables were compiled under the direction and superintendence of Mr. Henry S. Bright of Hull, and published by him in the year 1854. He has, in the most liberal way, placed them at my disposal for insertion in the Journal, and has had additional tables prepared, which make the series complete up to the present time. They contain, in small compass and accessible form, the principal statistics of the corn trade since the year 1828, as well as the average price of wheat for the last two centuries, and will be found valuable to the politician and the financier as well as to the farmer.—H. S. T.

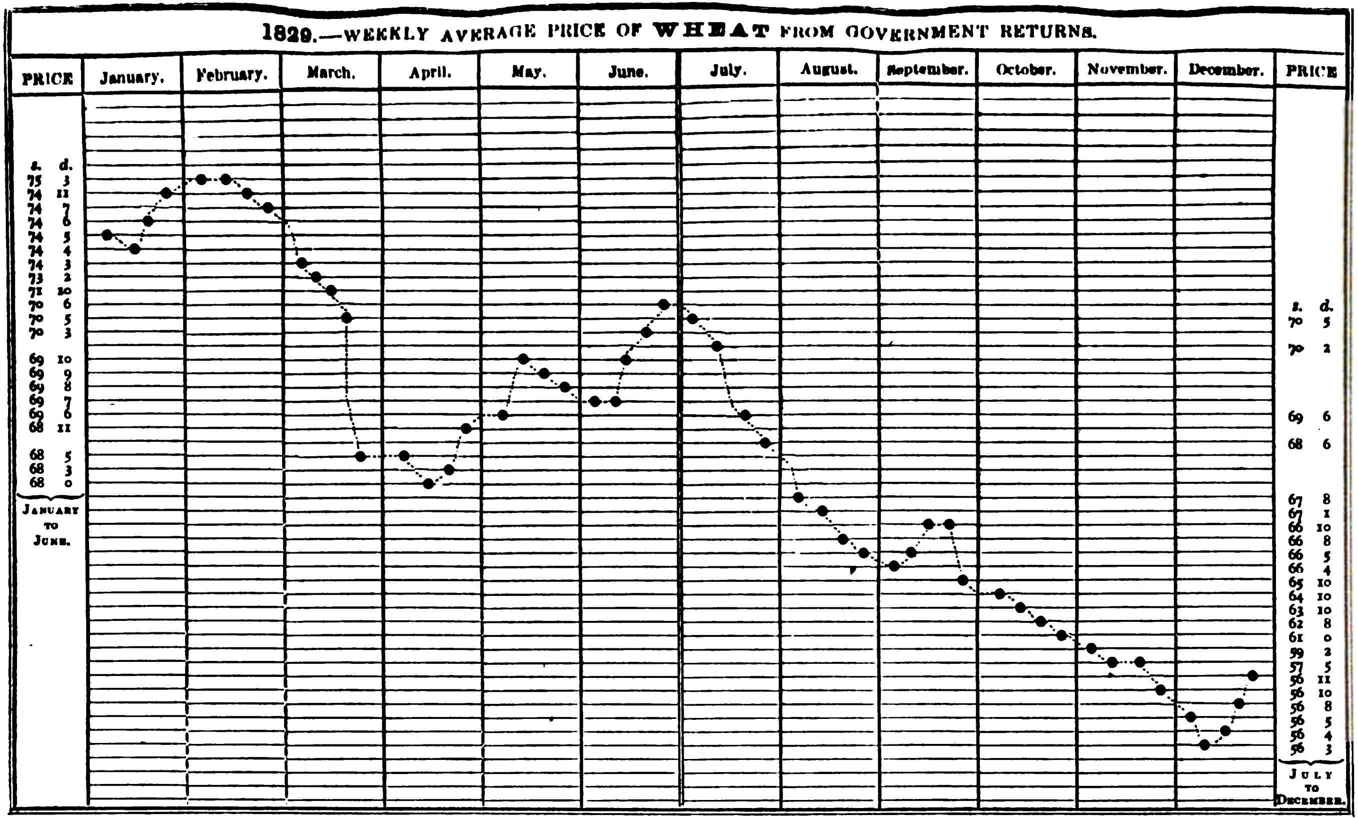
A TABLE SHOWING THE YEARLY AVERAGE PRICE OF WHEAT PER QR. FROM 1641.

A.D.	s.	d.	A.D.	s.	d.	A.D.	s.	d.	A.D.	s.	d.	A.D.	s.	d.	A.D.	s.	d.	A.D.	s.	d.	A.D.	s.	d.	A.D.	s.	d.	A.D.	s.	d.
1641	57	1	1663	50	8	1685	41	5	1707	25	4	1729	41	7	1751	34	2	1773	51	0	1795	75	2	1817	96	11	1839	70	6
1642	60	2	1664	36	0	1686	30	2	1708	36	10	1730	32	5	1752	37	2	1774	52	8	1796	78	7	1818	86	3	1840	66	4
1643	59	10	1665	43	10	1687	22	4	1709	69	9	1731	29	2	1753	39	8	1775	48	4	1797	53	9	1819	74	6	1841	64	5
1644	61	3	1666	32	0	1688	40	10	1710	69	4	1732	23	8	1754	30	9	1776	38	2	1798	51	10	1820	67	10	1842	57	5
1645	51	3	1667	32	0	1689	26	8	1711	48	0	1733	25	2	1755	30	1	1777	45	6	1799	69	0	1821	56	1	1843	50	2
1646	42	8	1668	35	6	1690	30	9	1712	41	2	1734	30	9	1756	40	1	1778	42	0	1800	113	10	1822	44	7	1844	51	3
1647	65	5	1669	39	5	1691	30	2	1713	45	4	1735	38	2	1757	53	4	1779	33	8	1801	119	6	1823	53	4	1845	50	9
1648	75	6	1670	37	0	1692	41	5	1714	44	9	1736	35	10	1758	44	5	1780	35	8	1802	69	10	1824	63	11	1846	54	9
1649	71	1	1671	37	4	1693	60	1	1715	38	2	1737	33	9	1759	35	3	1781	44	8	1803	58	10	1825	68	6	1847	69	5
1650	68	1	1672	36	5	1694	56	10	1716	42	8	1738	31	6	1760	32	5	1782	47	10	1804	62	3	1826	58	8	1848	50	6
1651	65	2	1673	41	5	1695	47	1	1717	40	7	1739	34	2	1761	26	9	1783	52	8	1805	89	9	1827	58	6	1849	44	6
1652	44	0	1674	61	0	1696	63	1	1718	34	6	1740	45	1	1762	34	8	1784	48	10	1806	79	1	1828	60	5	1850	40	4
1653	31	6	1675	57	5	1697	53	4	1719	31	1	1741	41	5	1763	36	1	1785	51	10	1807	75	4	1829	66	3	1851	38	7
1654	23	1	1676	33	9	1698	60	9	1720	32	10	1742	30	2	1764	41	5	1786	38	10	1808	81	4	1830	64	3	1852	41	0
1655	29	7	1677	37	4	1699	56	10	1721	33	4	1743	22	1	1765	48	0	1787	41	2	1809	97	4	1831	66	4	1853	53	3
1656	38	2	1678	52	5	1700	35	6	1722	32	0	1744	22	1	1766	43	1	1788	45	0	1810	106	5	1832	58	8	1854	72	7
1657	41	5	1679	53	4	1701	33	5	1723	30	10	1745	24	5	1767	47	4	1789	51	2	1811	95	3	1833	52	11	1855	74	9
1658	57	9	1680	40	0	1702	26	2	1724	32	10	1746	34	8	1768	53	9	1790	54	9	1812	126	6	1834	46	2	1856		
1659	58	8	1681	41	5	1703	32	0	1725	43	1	1747	30	11	1769	40	7	1791	48	7	1813	109	9	1835	39	4	1857		
1660	50	2	1682	39	1	1704	41	4	1726	40	10	1748	32	10	1770	43	6	1792	43	0	1814	74	4	1836	48	9	1858		
1661	62	2	1683	35	6	1705	26	8	1727	37	4	1749	32	10	1771	47	2	1793	49	3	1815	65	7	1837	55	10	1859		
1662	65	9	1684	39	1	1706	23	1	1728	48	5	1750	28	10	1772	50	8	1794	52	3	1816	78	6	1838	64	4	1860		

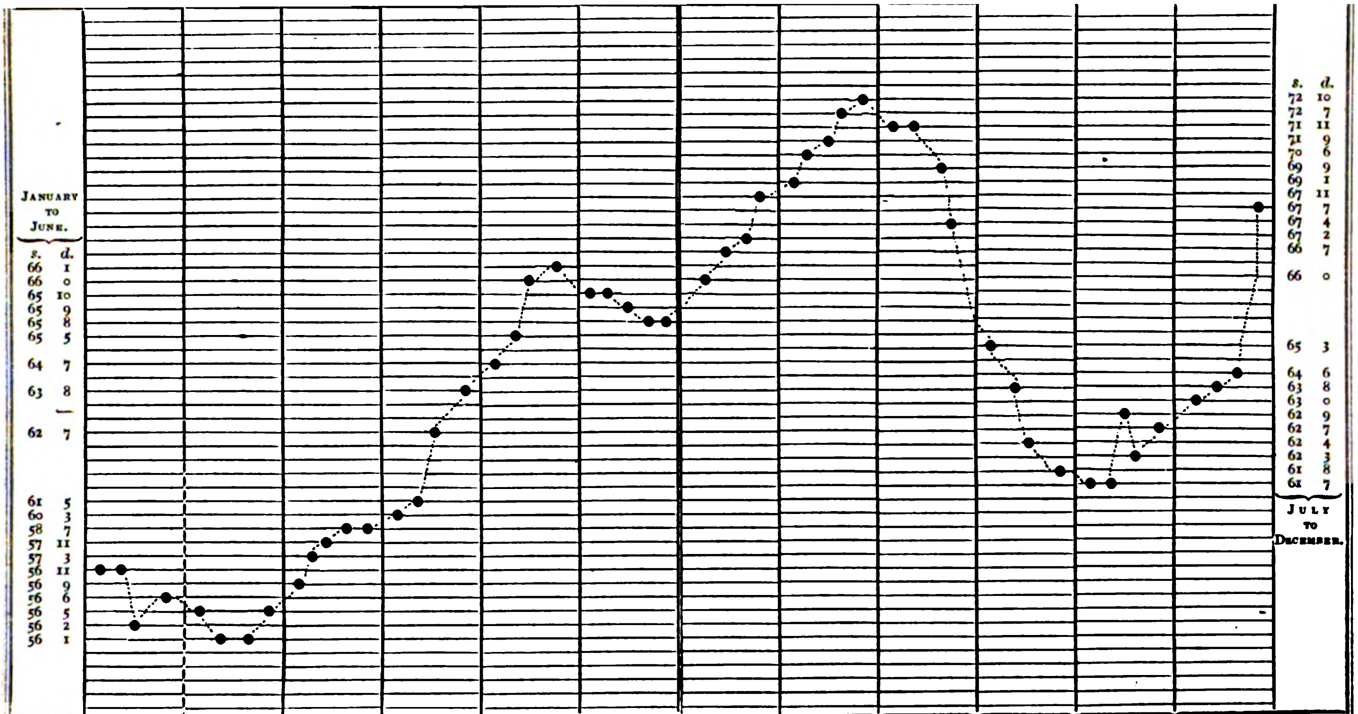
1828.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	60/5	32/10	22/6	38/4	40/6	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

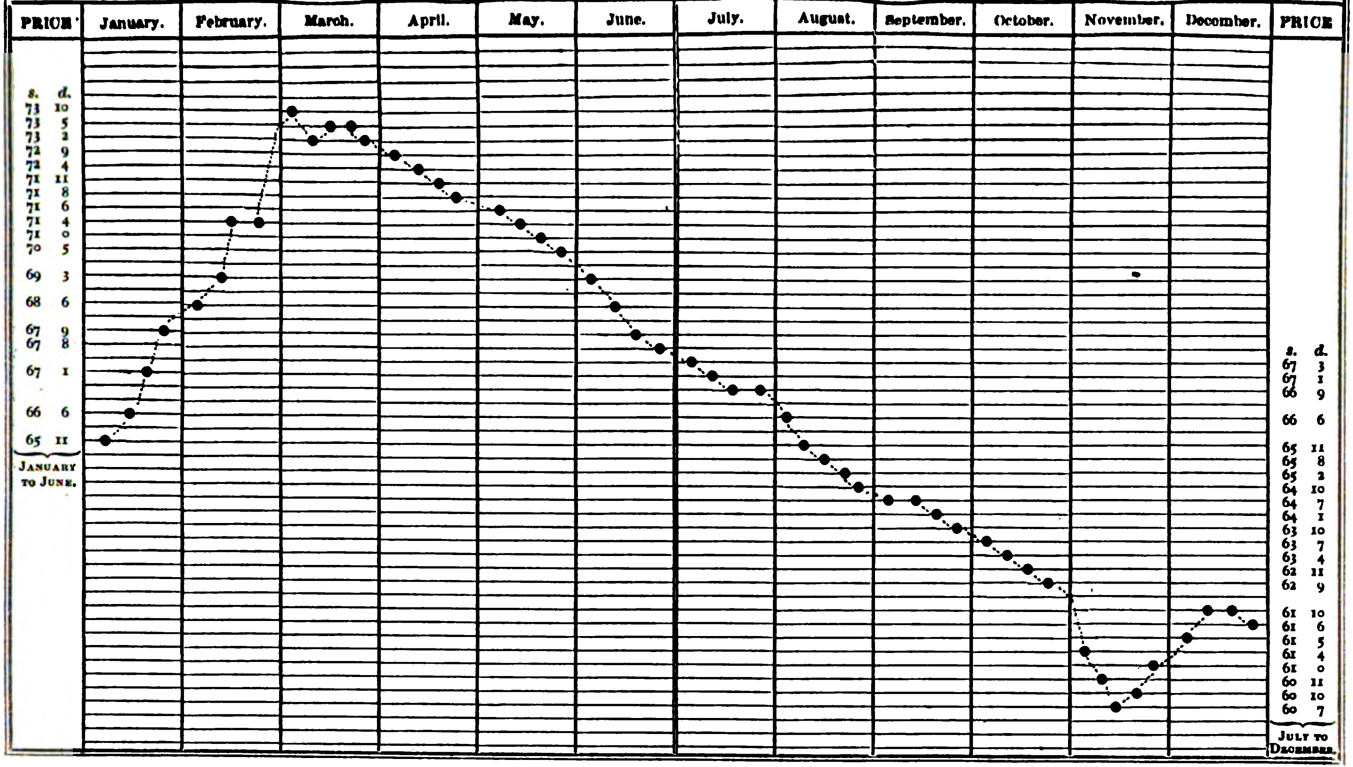


	Wheat.	Barley	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	66/3	32/6	22/9	36/8	36/8	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.
Import of United Kingdom .	1,544,969	305,798	541,858	46,487	40,412	27,022	461,895 0 25



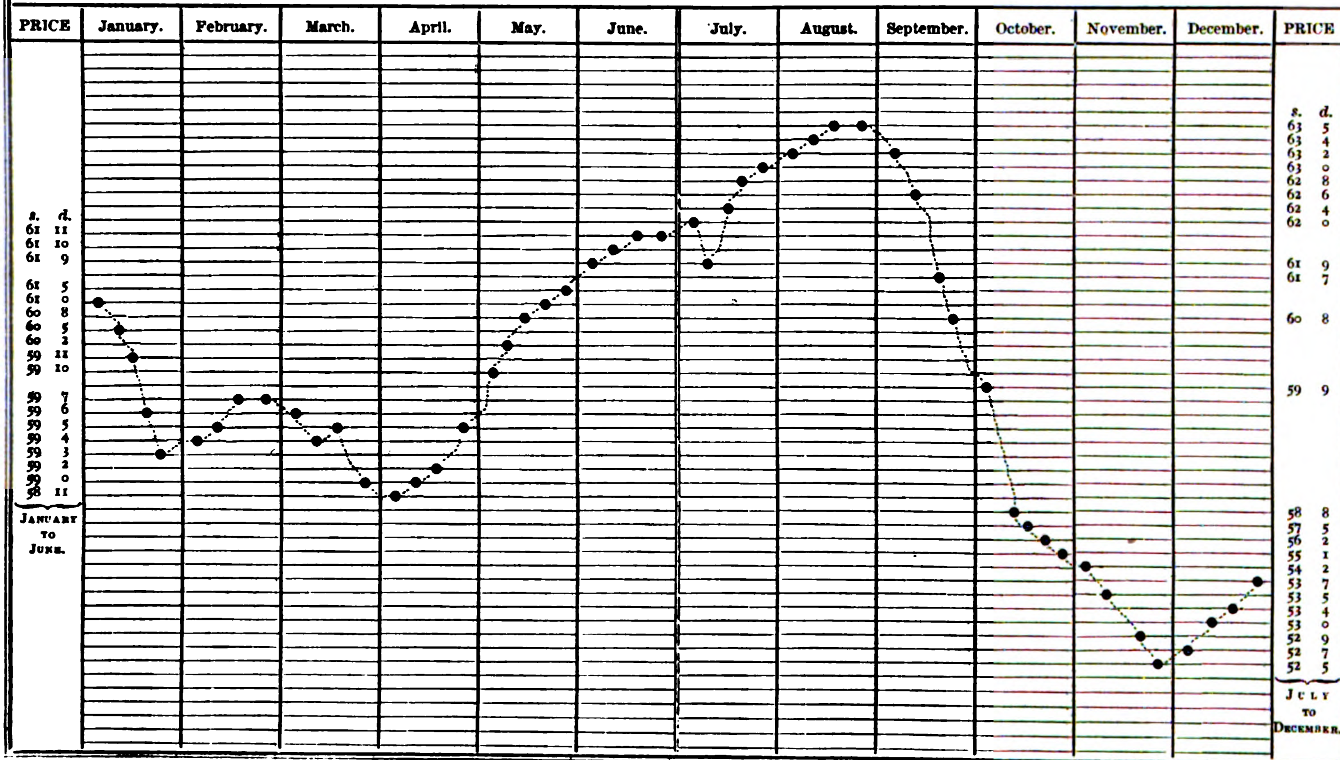
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	64/3	32/7	24/5	36/1	39/2	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts. qrs. lbs.*

1831.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.



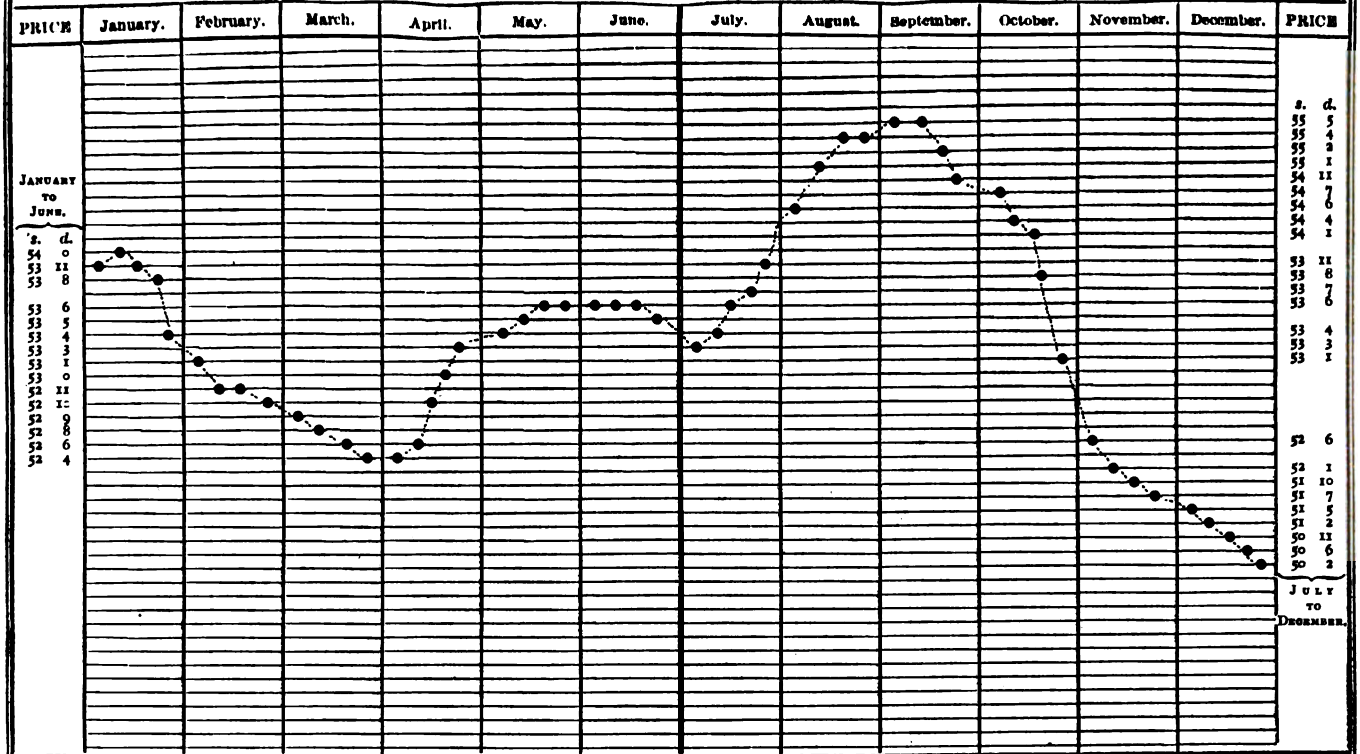
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	66/4	38/0	25/4	39/1	41/11	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.
Import of United Kingdom .	1,857,278	369,032	617,568	22,345	59,507	59,232	1,617,742 1 0

1832.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



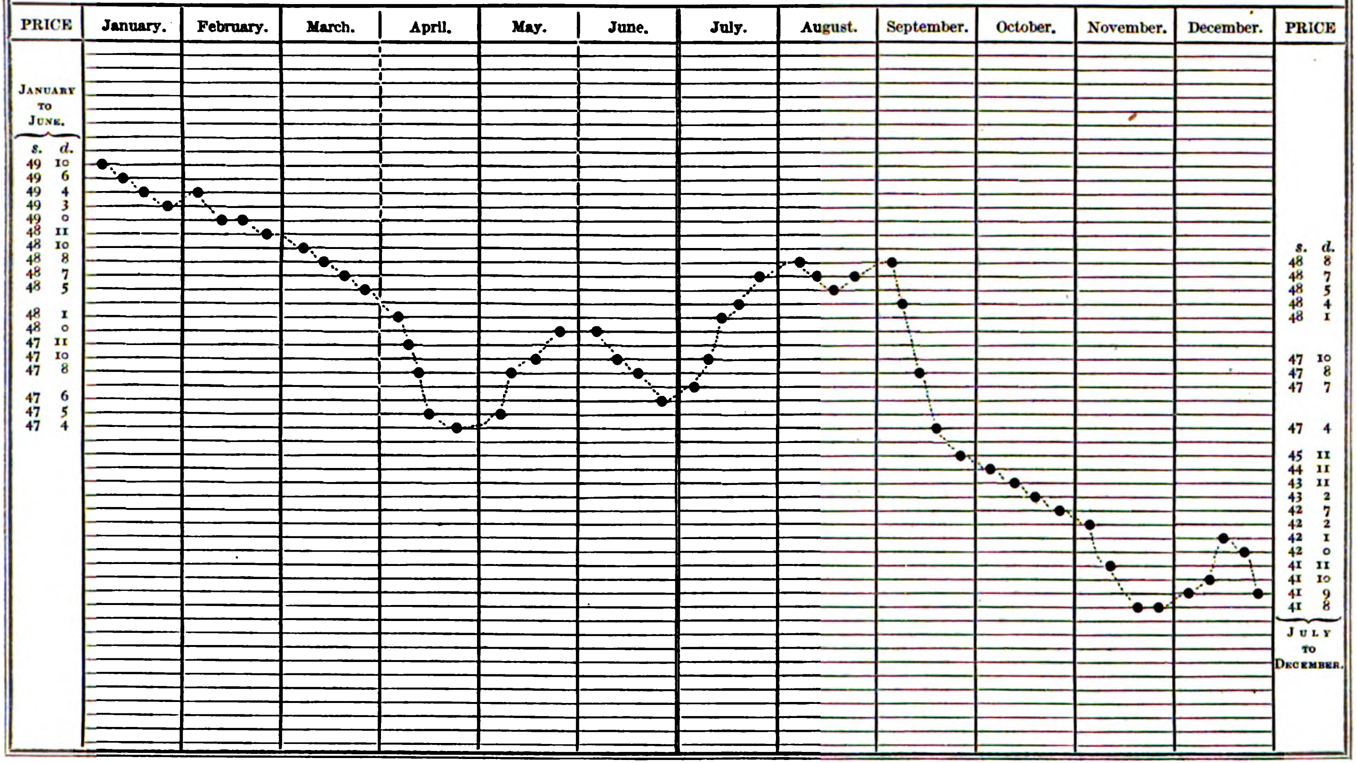
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	58/8	33/1	20/5	36/5	37/0	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1883.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.



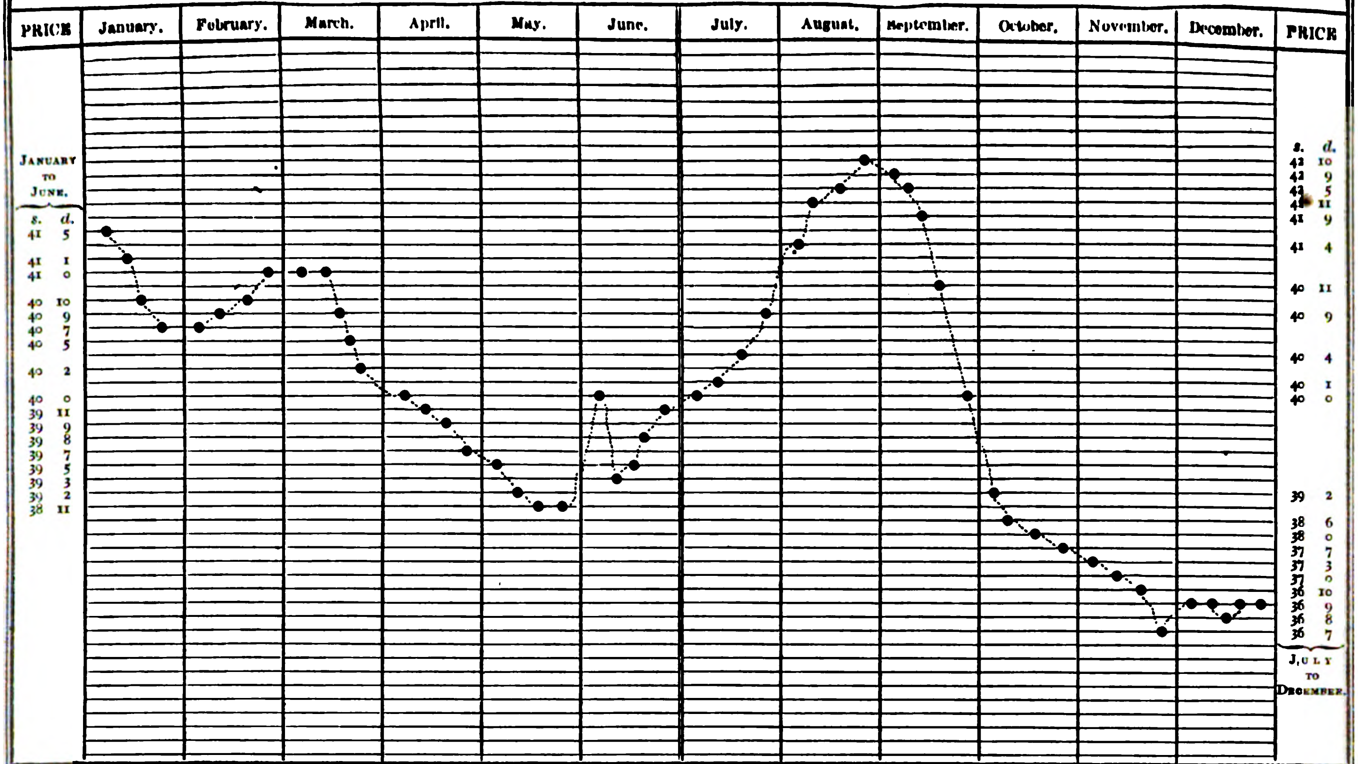
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	52/11	27/6	18/5	35/1	37/0	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts. qrs. lbs.*
Import of United Kingdom .	247,625	85,221	23,335	22,857	15,890	7	170,092 3 14

1834.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.

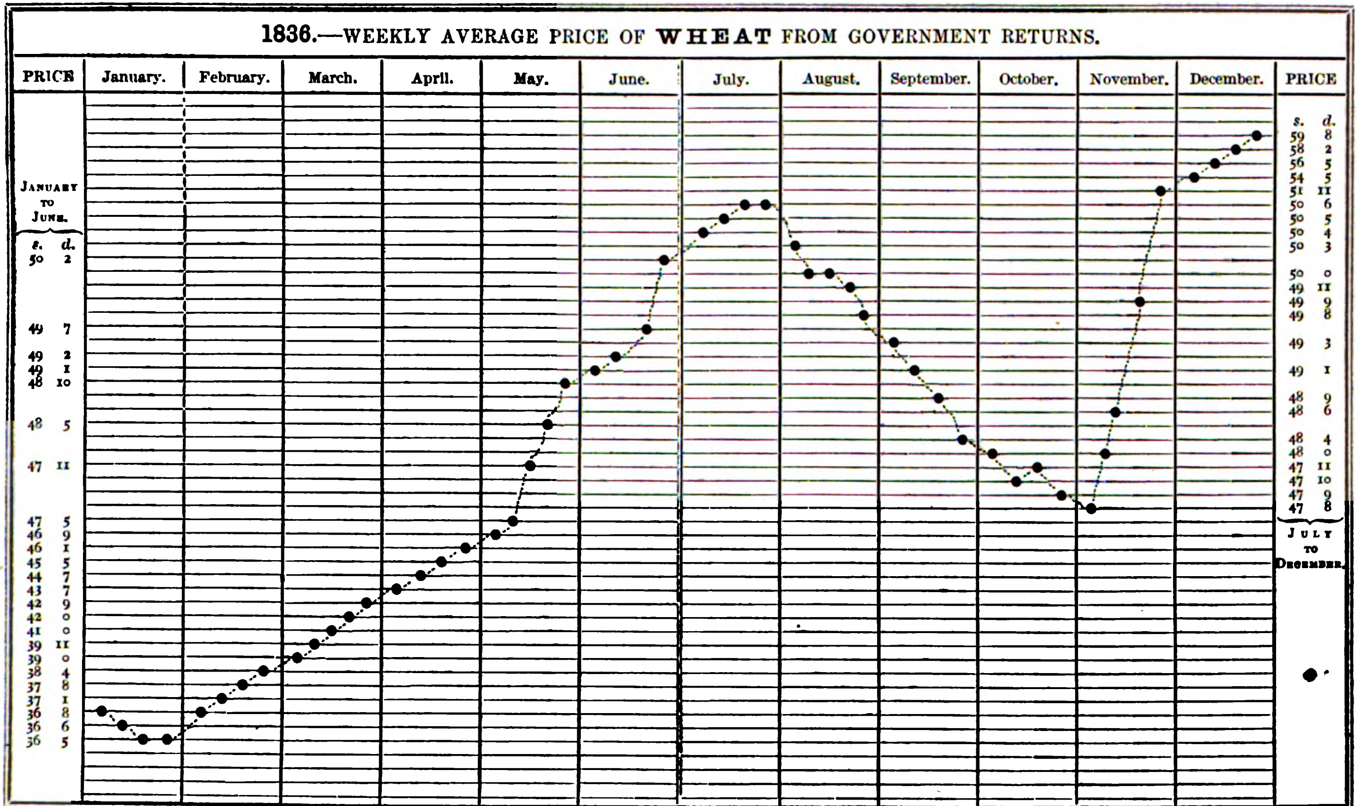


	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	46/2	29/0	20/11	36/7	33/0	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1835. —WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.

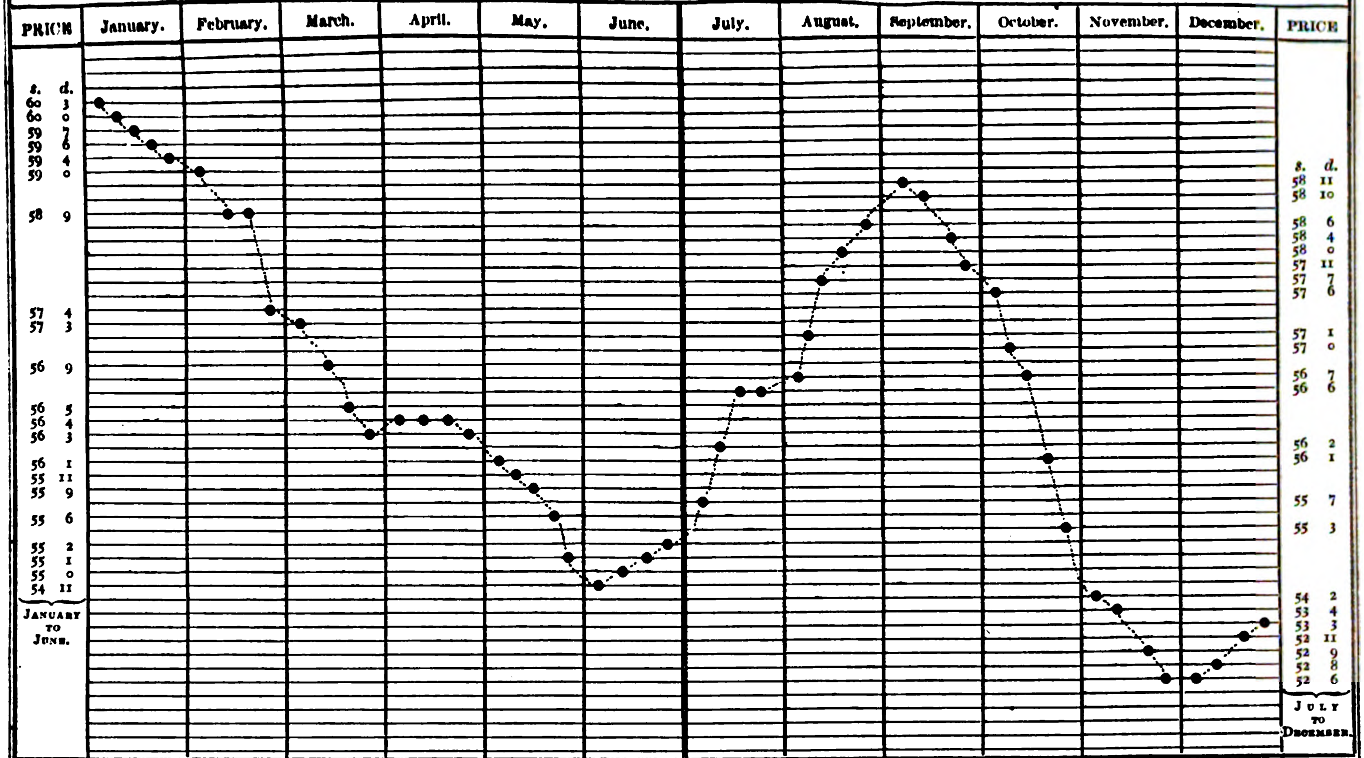


	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	39/4	29/11	22/0	30/0	30/3	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts. qrs. lbs.*
Import of United Kingdom .	46,530	67,796	117,673	34,380	24,216	1,808	84,684 2 16



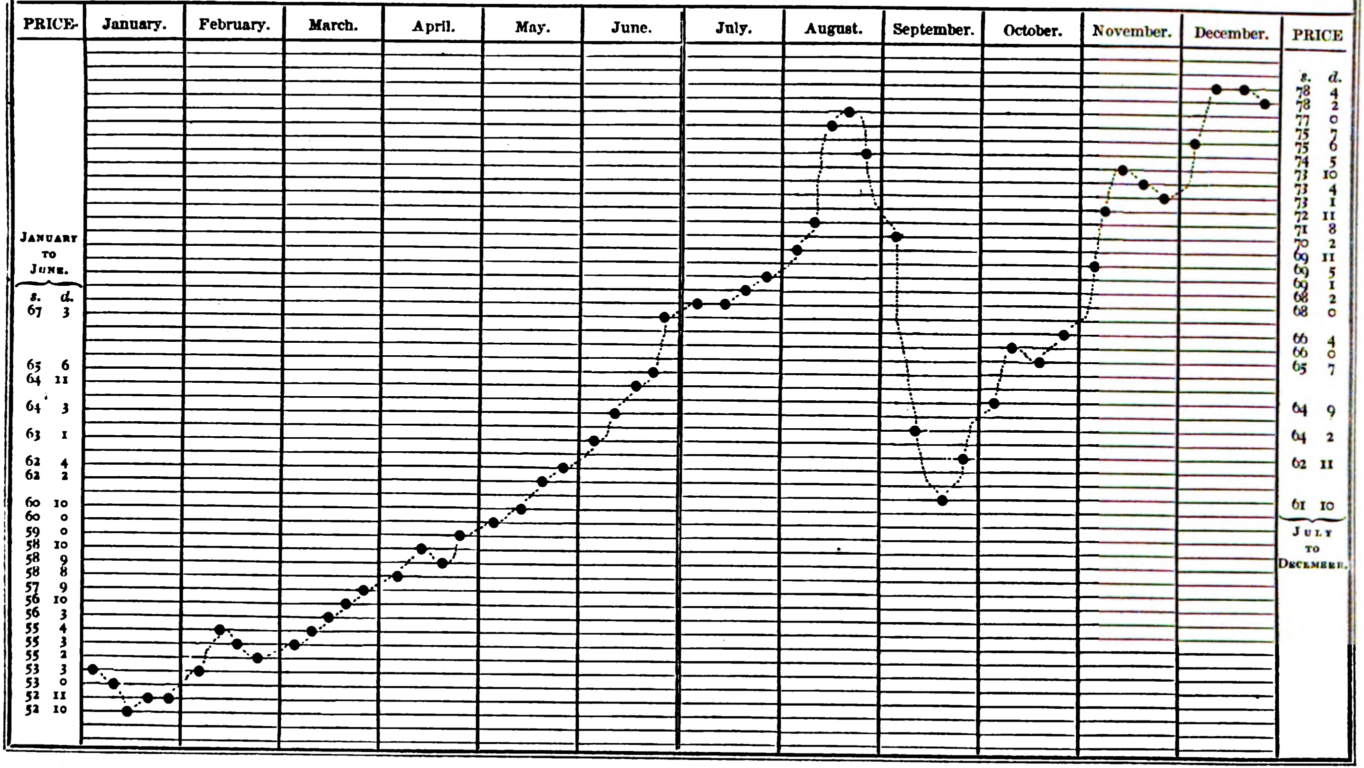
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	48/9	33/2	23/1	38/4	37/3	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1837.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



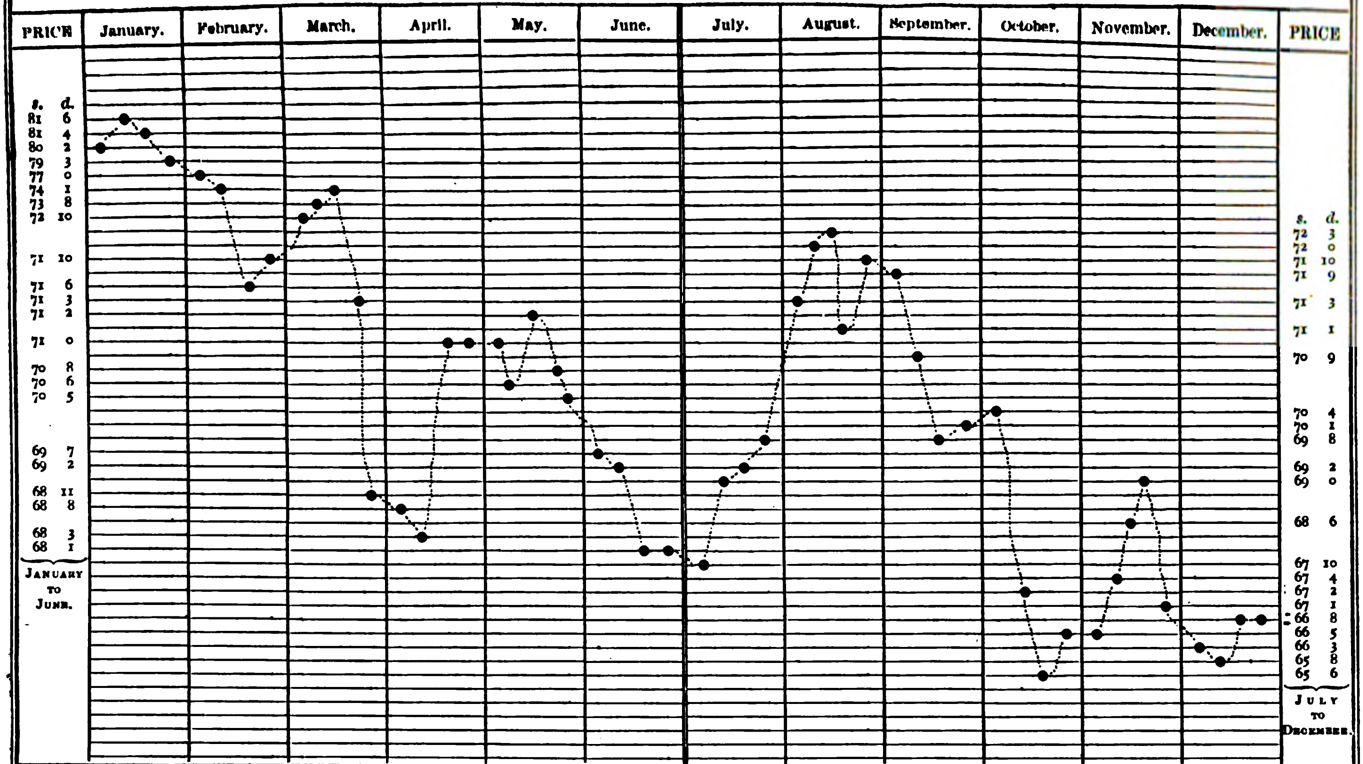
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	55/10	30/4	23/1	38/7	37/9	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts.* *qrs.* *lbs.*
Import of United Kingdom .	452,369	87,791	413,710	105,671	111,264	4,026	346,325 3 18

1838.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.



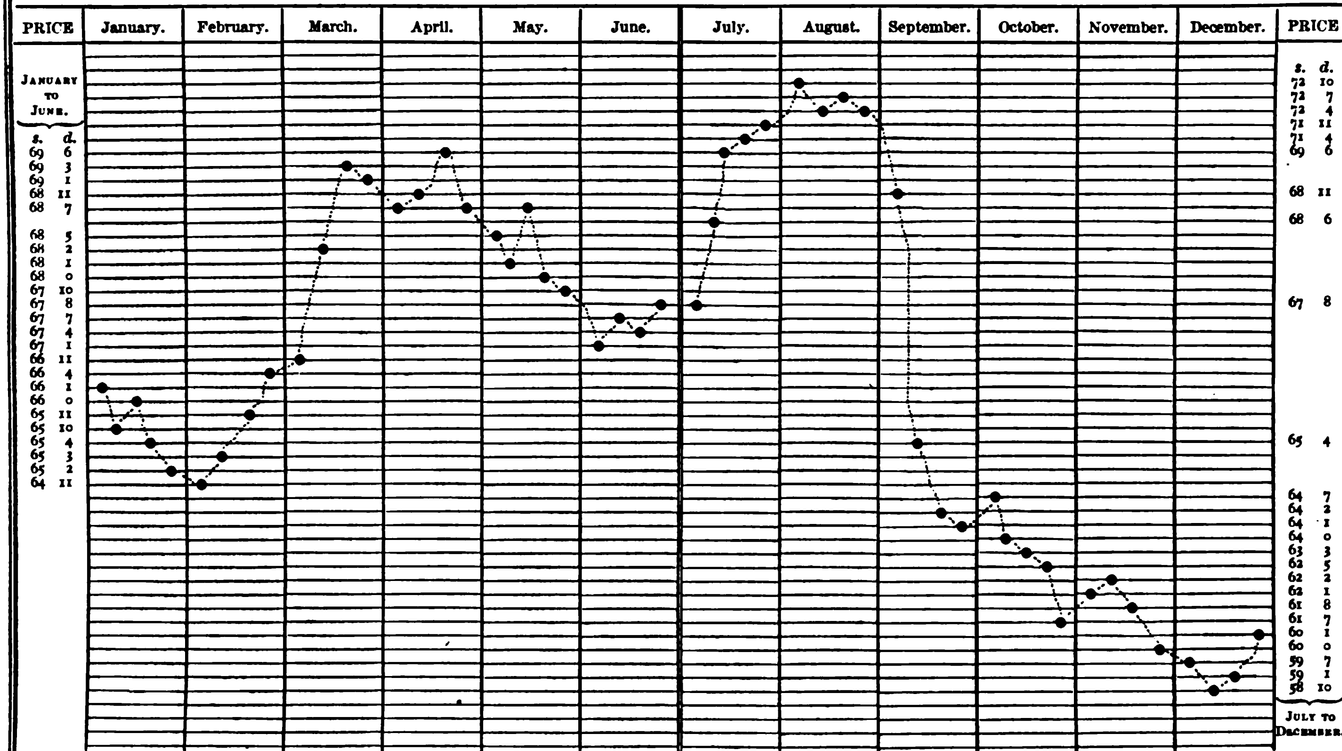
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	64/4	31/5	22/5	37/4	36/8	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1839.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



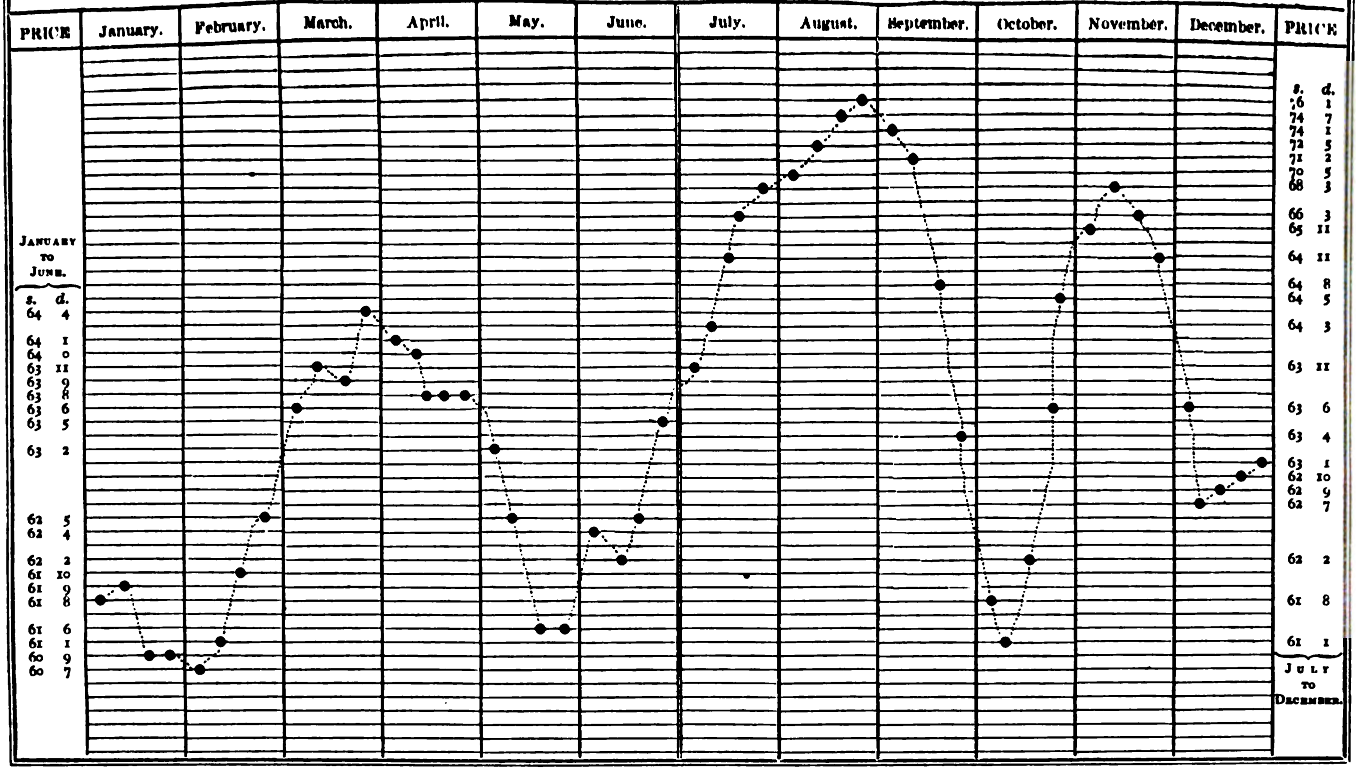
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	70/6	39/1	26/6	41/3	41/1	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts.* *qrs.* *lbs.*
Import of United Kingdom .	2,638,593	579,405	674,554	109,810	140,012	9,565	793,606 1 6

1840.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.



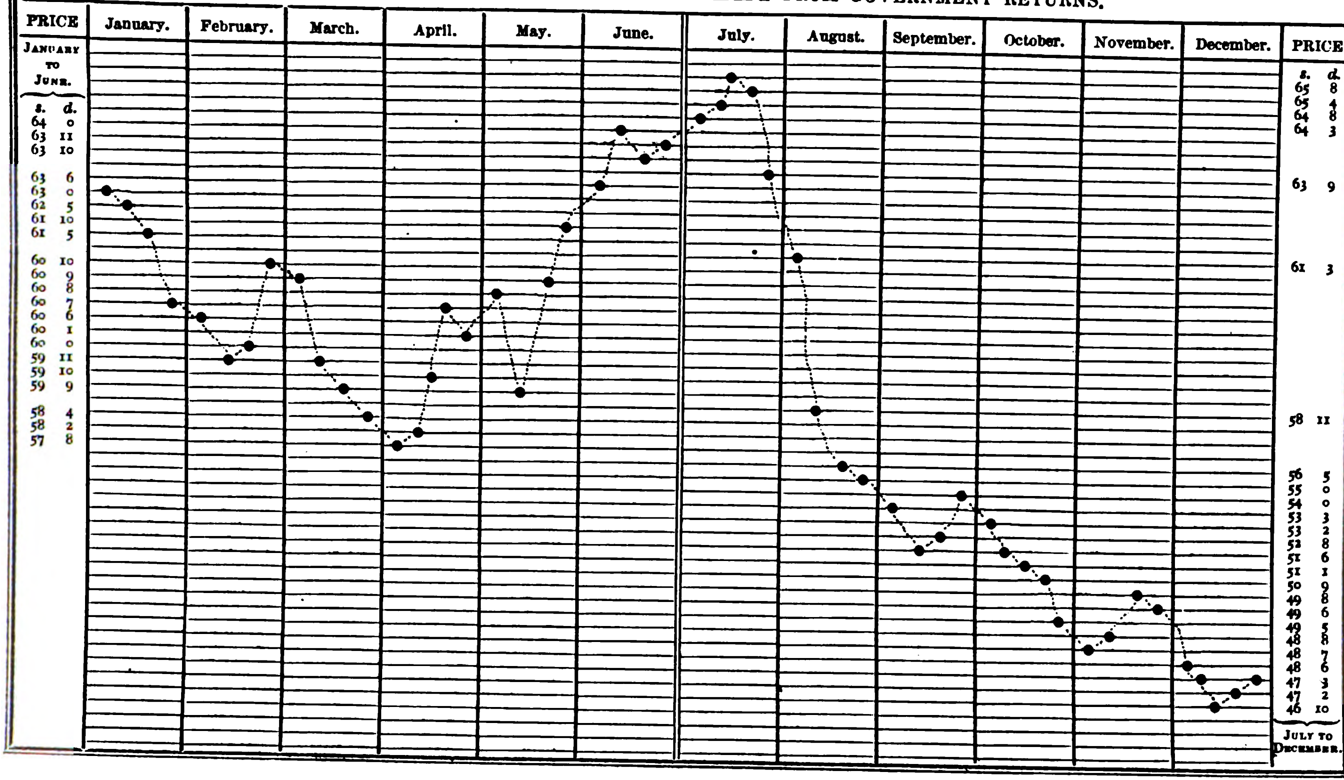
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	66/4	36/3	25/9	43/6	42/5	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1841.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



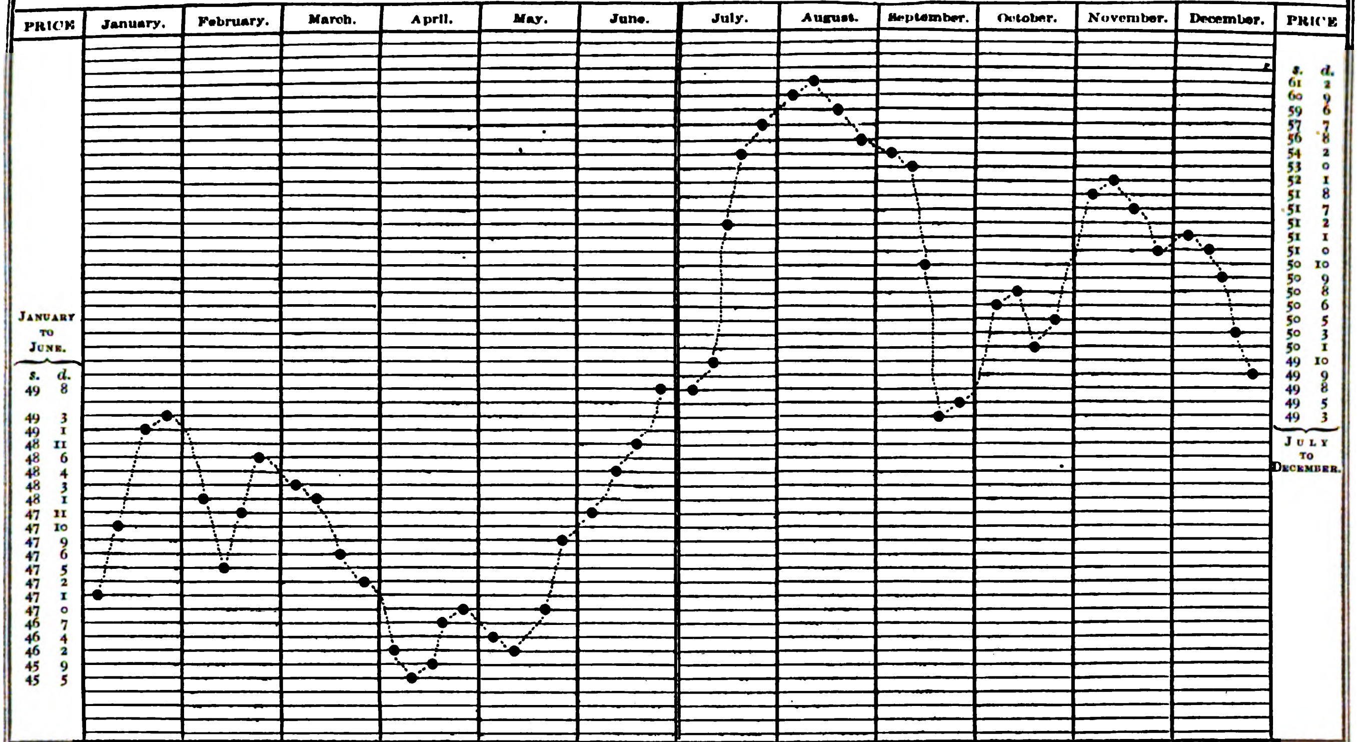
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	64/5	33/0	22/5	40/5	39/1	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts. qrs. lbs.*
Import of United Kingdom .	2,409,754	264,654	122,297	293,689	148,564	4,137	1,275,656 0 0

1842.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



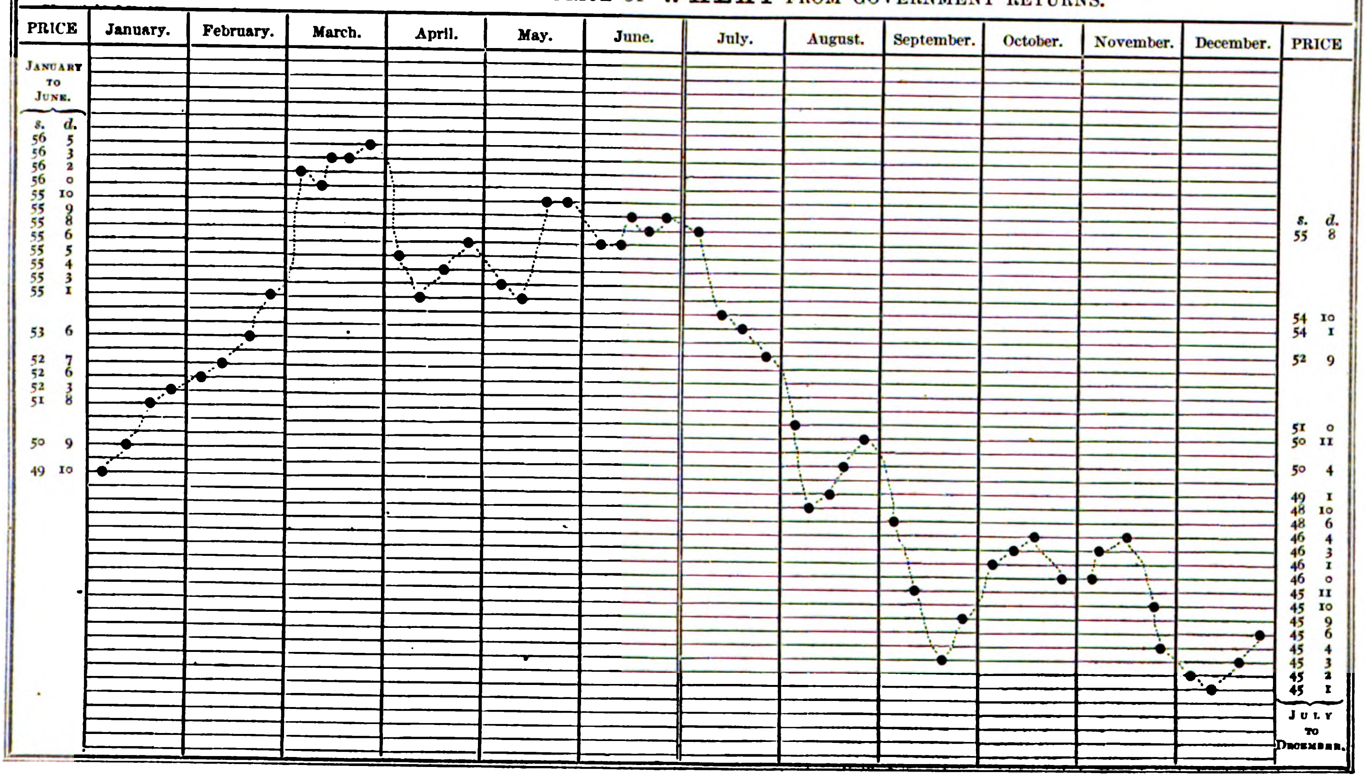
		Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	. . . .	57/5	27/6	19/3	32/8	32/11	..	..
		qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1843.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.

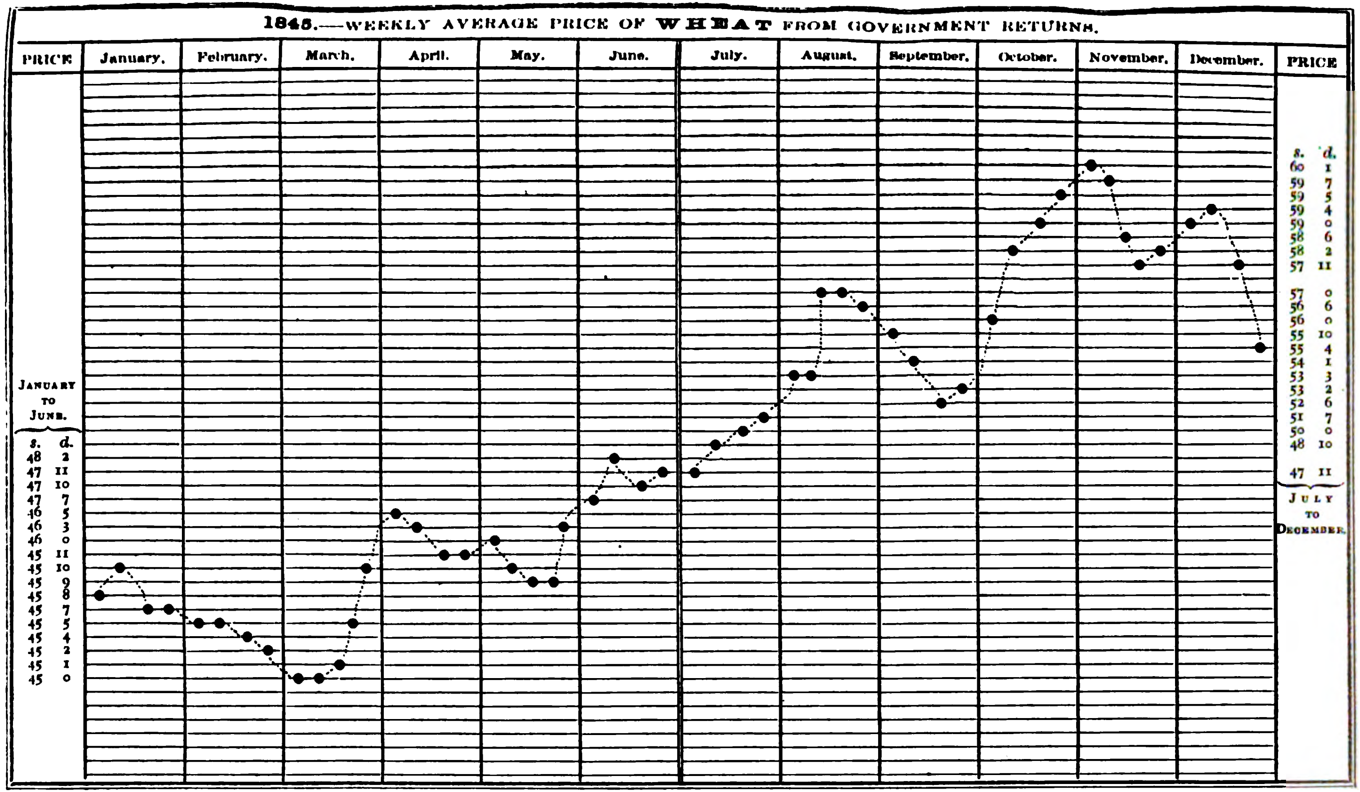


	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	50/2	29/5	18/3	29/1	31/1	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.
Import of United Kingdom .	932,866	179,414	84,718	48,080	48,971	516	440,955 3 23

1844.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.

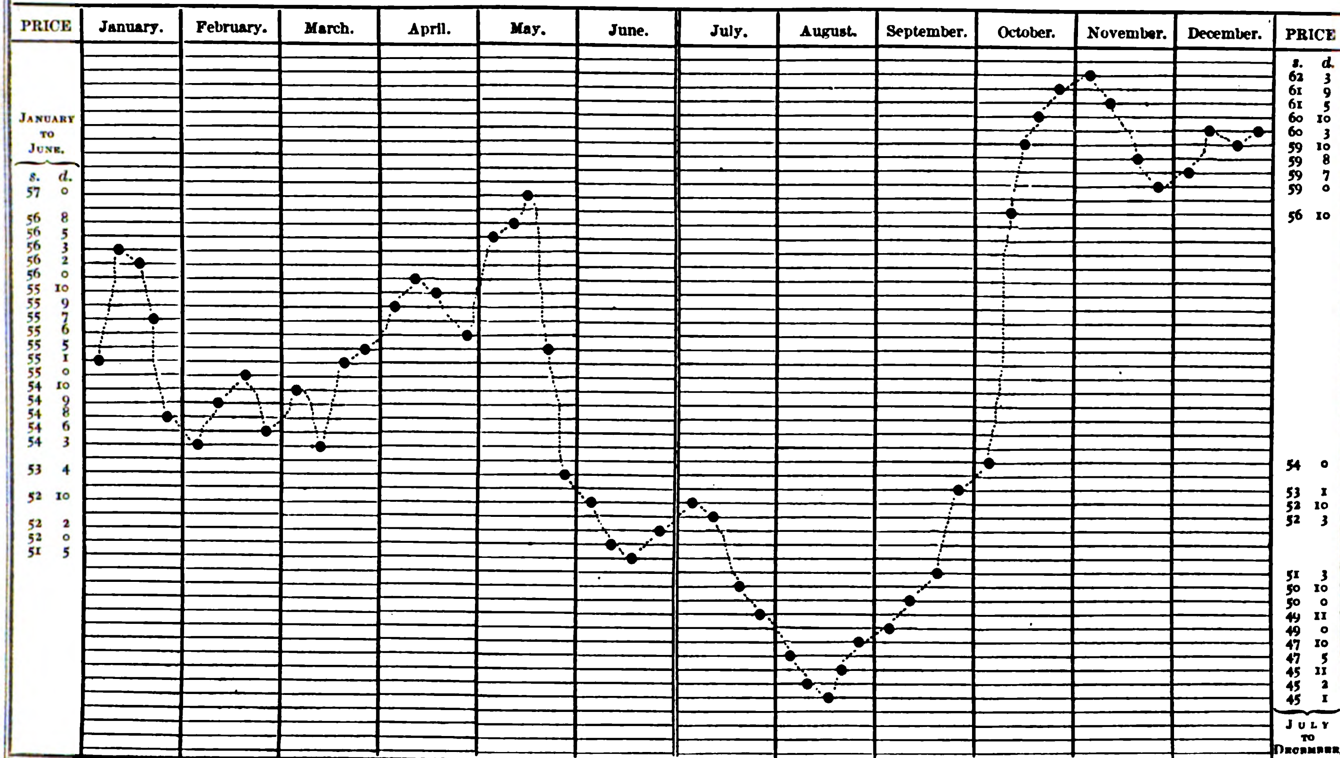


Average of Year	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
	51/3	33/7	20/7	34/6	33/5	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.



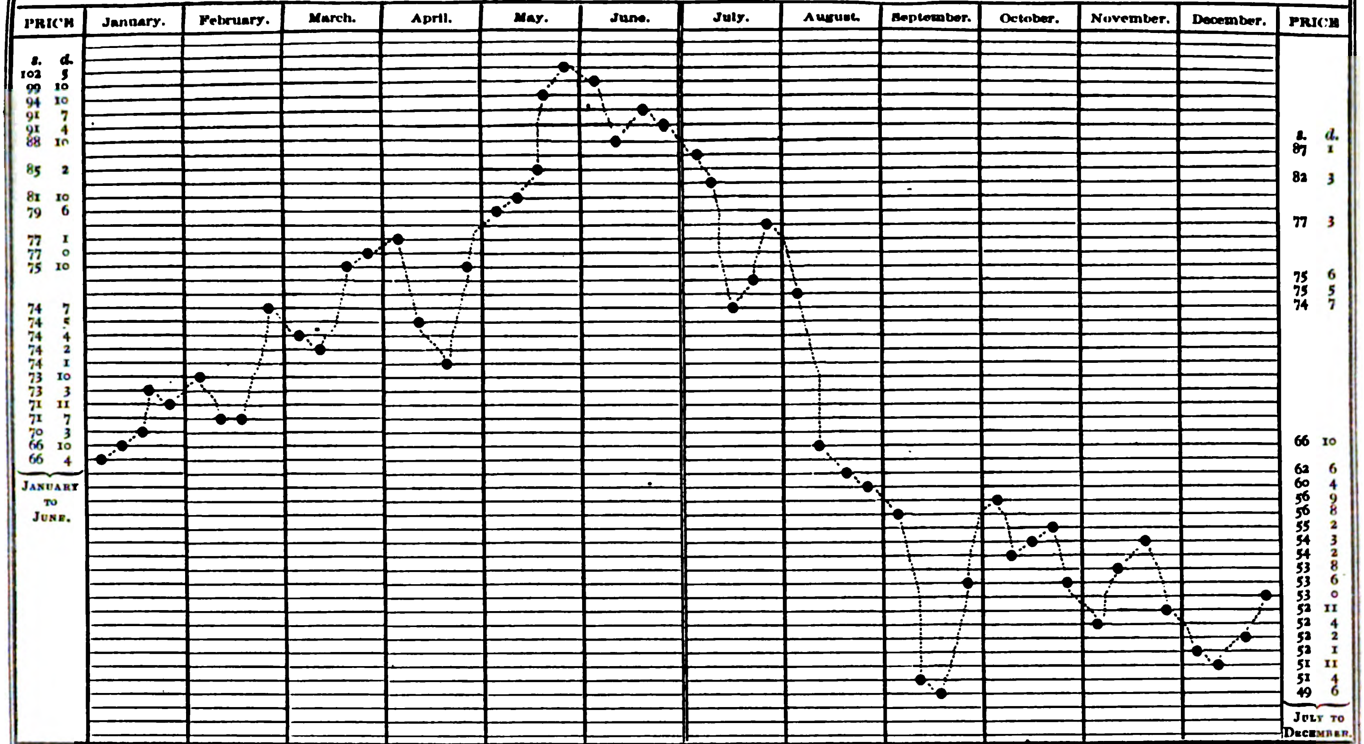
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	50/9	31/8	22/6	39/0	38/6	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts. qrs. lbs.*
Import of United Kingdom .	844,533	367,854	586,860	185,008	80,613	55,984	924,256 2 26

1846.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.



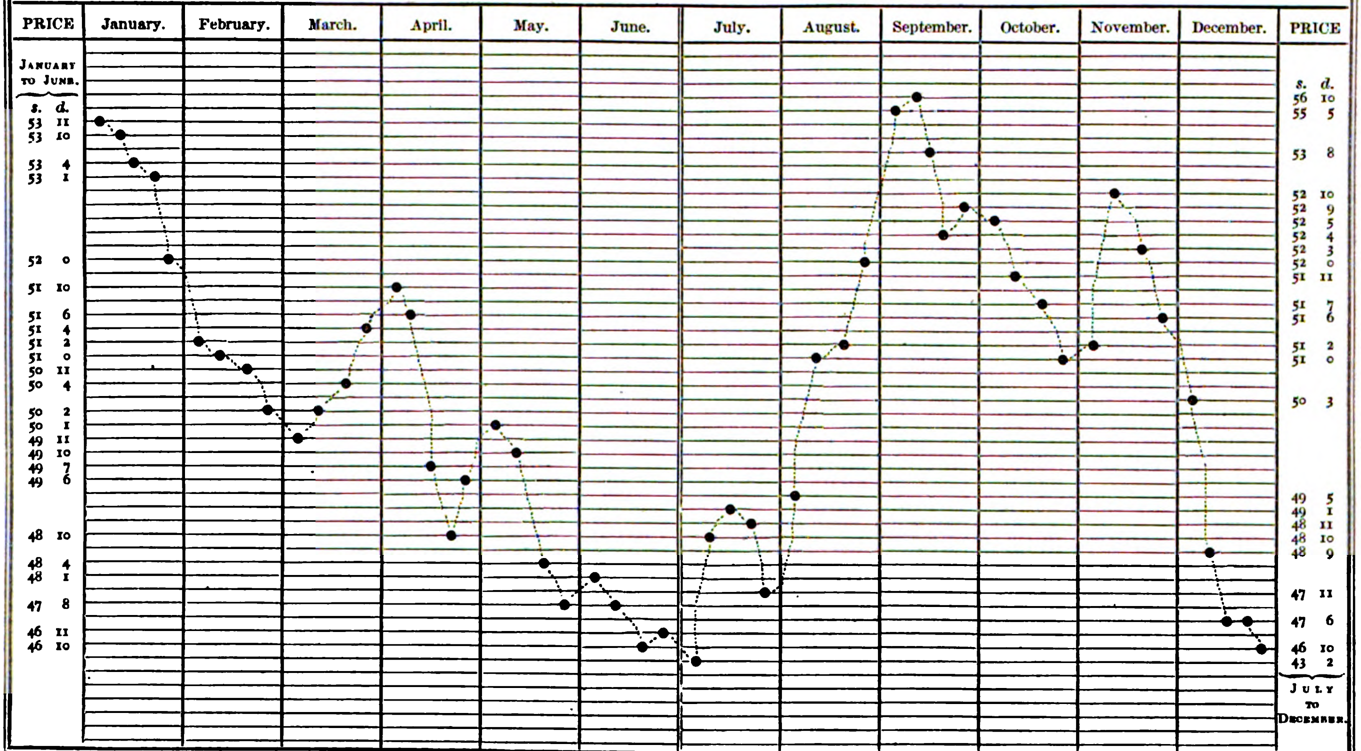
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	54/9	32/9	23/8	39/0	39/0	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1847.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



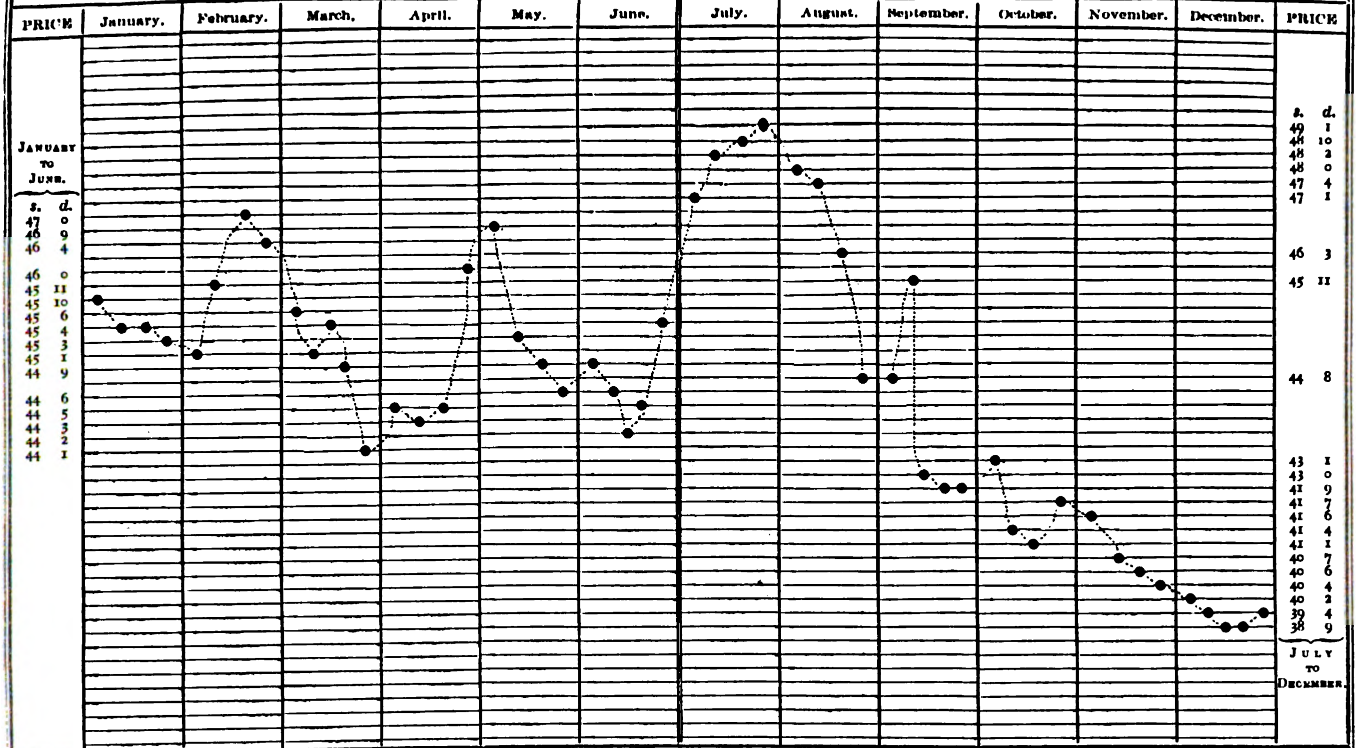
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	69/5	43/11	28/7	50/1	51/5	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts. qrs. lbs.*
Import of United Kingdom .	2,650,058	772,840	1,706,780	443,719	157,245	3,614,637	8,637,377 1 9

1848.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.



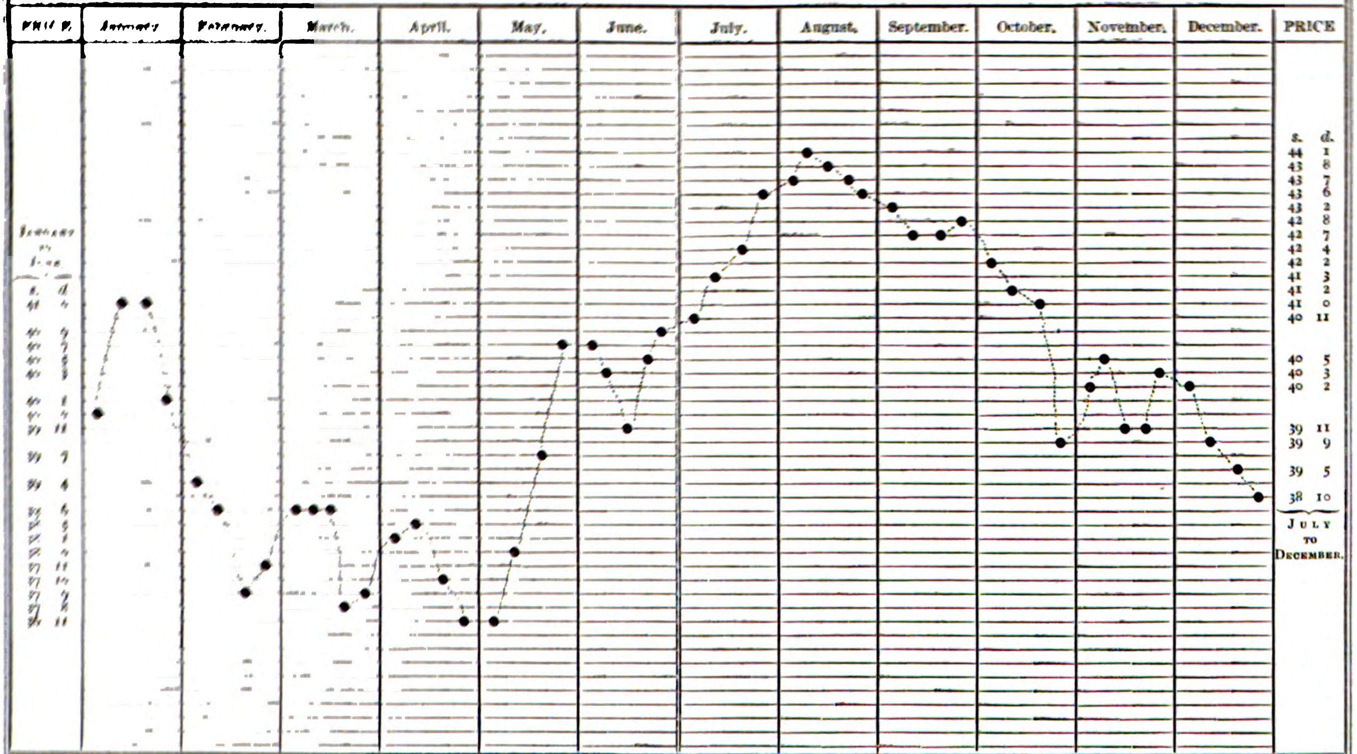
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	50/6	31/6	20/6	36/9	39/1	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1840.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.

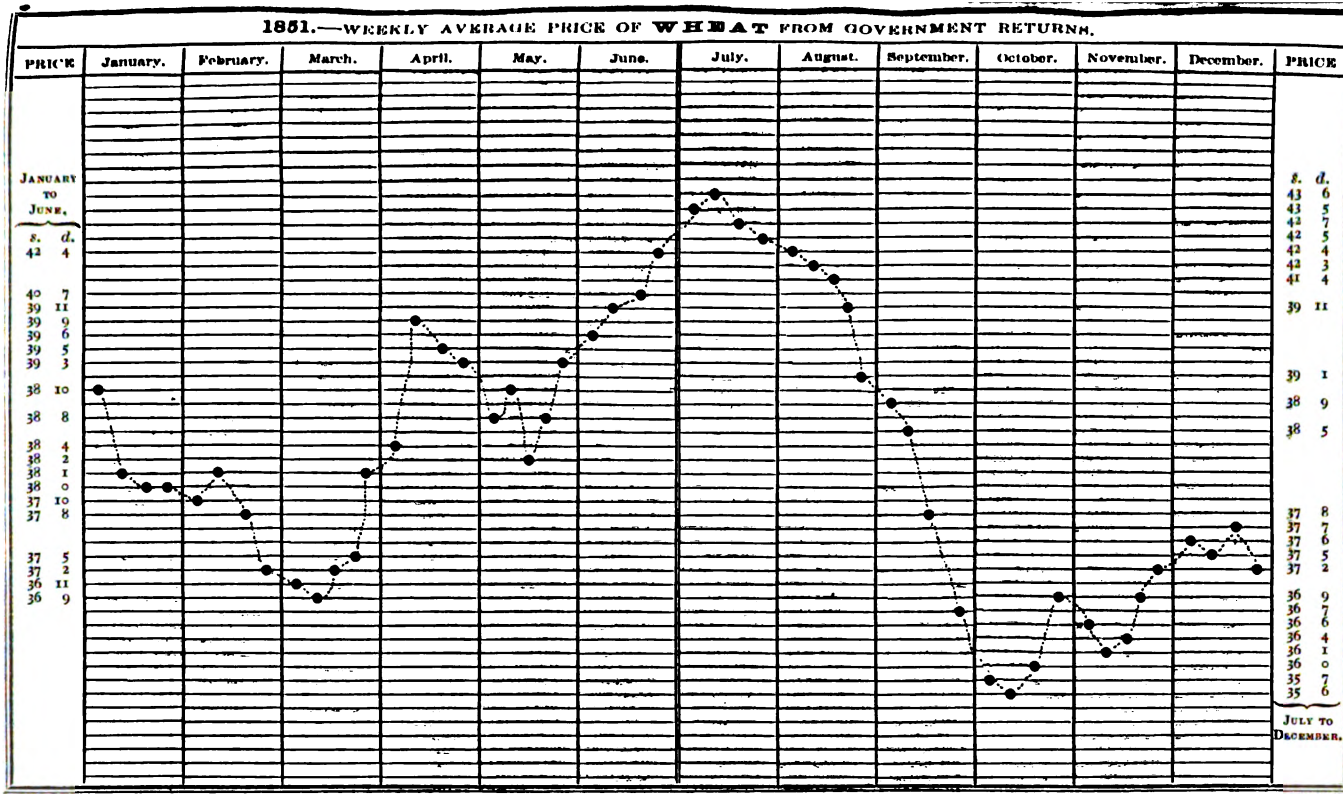


	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	44/6	27/9	17/6	30/3	31/3	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts.* *qrs.* *lbs.*
Import of United Kingdom .	3,872,568	1,388,494	1,281,517	456,023	236,067	2,189,164	3,483,294 0 0

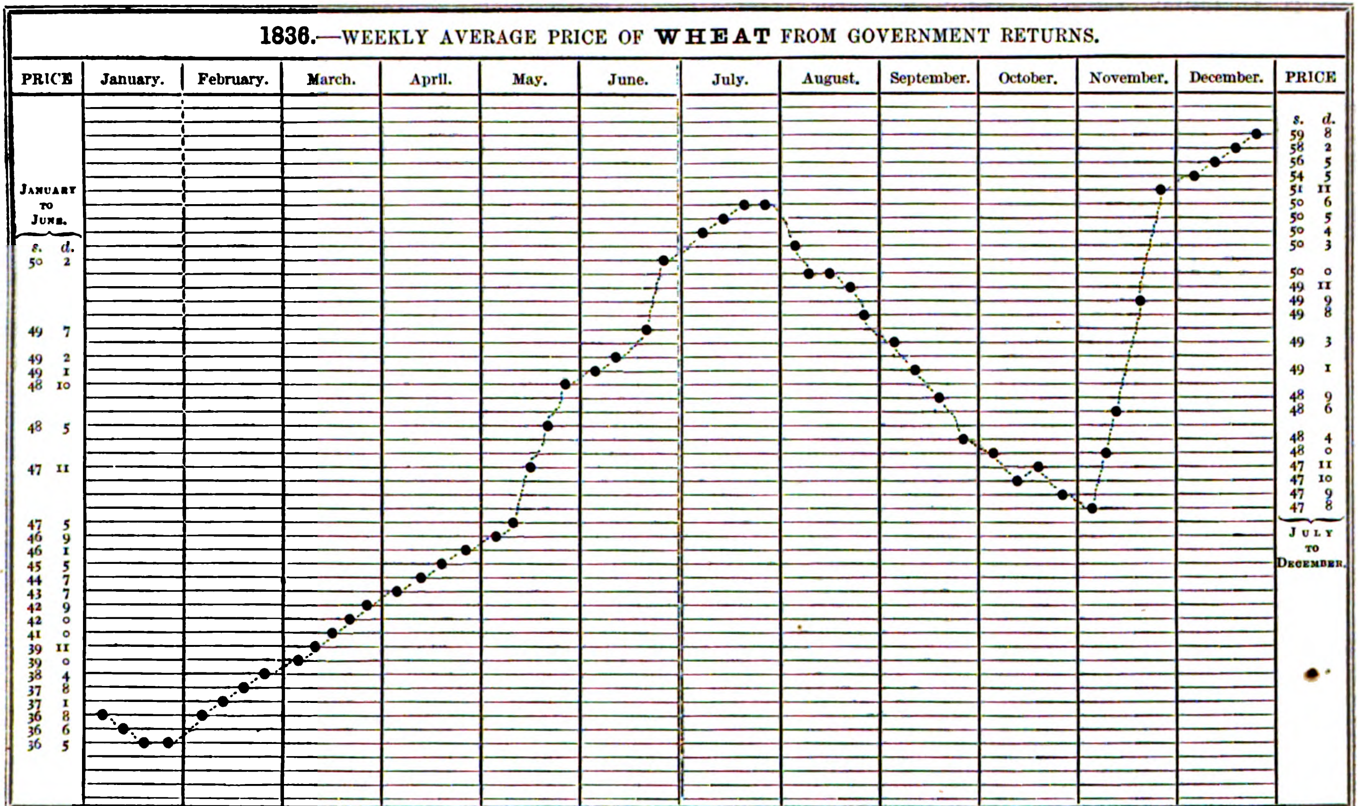
1850.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



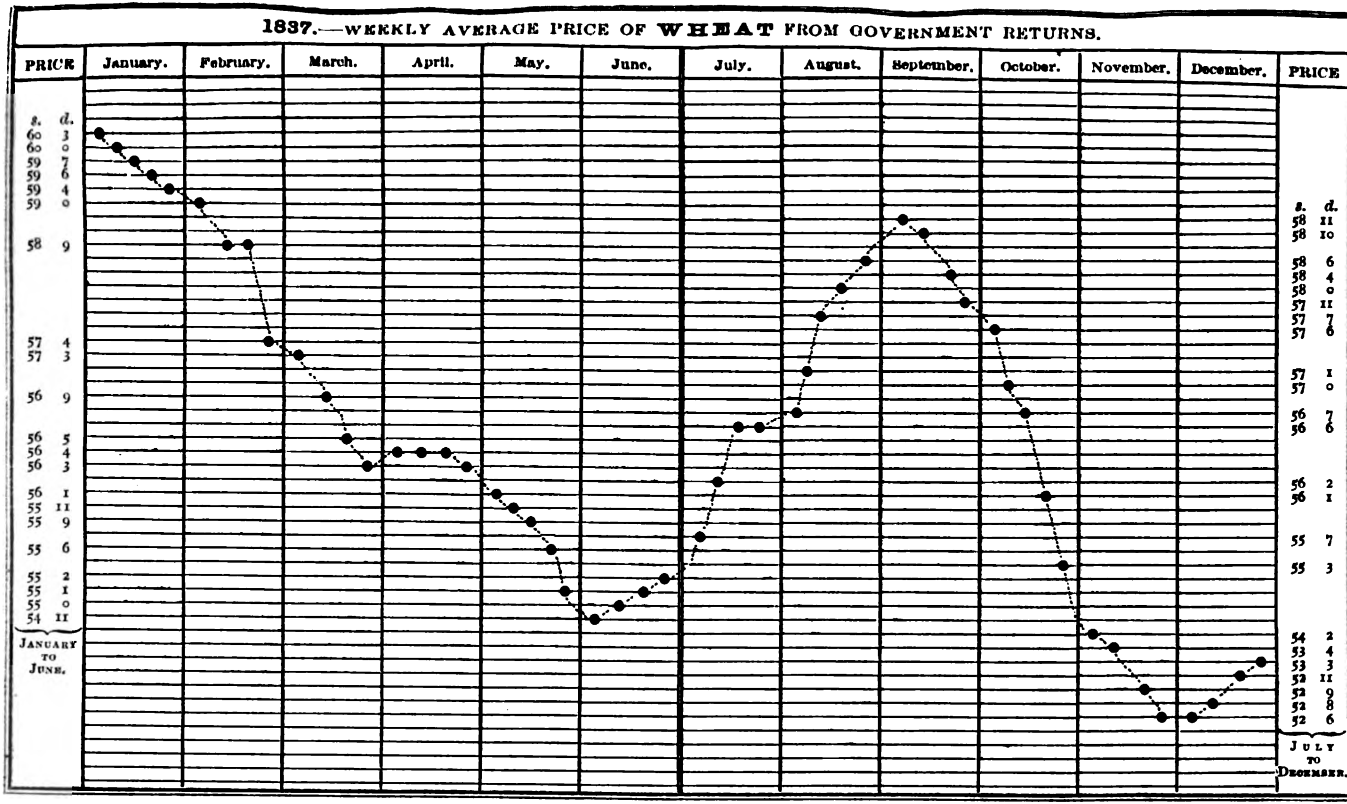
Average of Year	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
. . . .	40/4	23/5	16/5	26/11	27/5	. .	. .
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.



	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	38/7	24/9	18/7	28/9	27/3	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts.* *qrs.* *lbs.*
Import of United Kingdom .	3,831,836	834,491	1,209,844	318,502	100,392	1,821,573	5,363,478 1 26

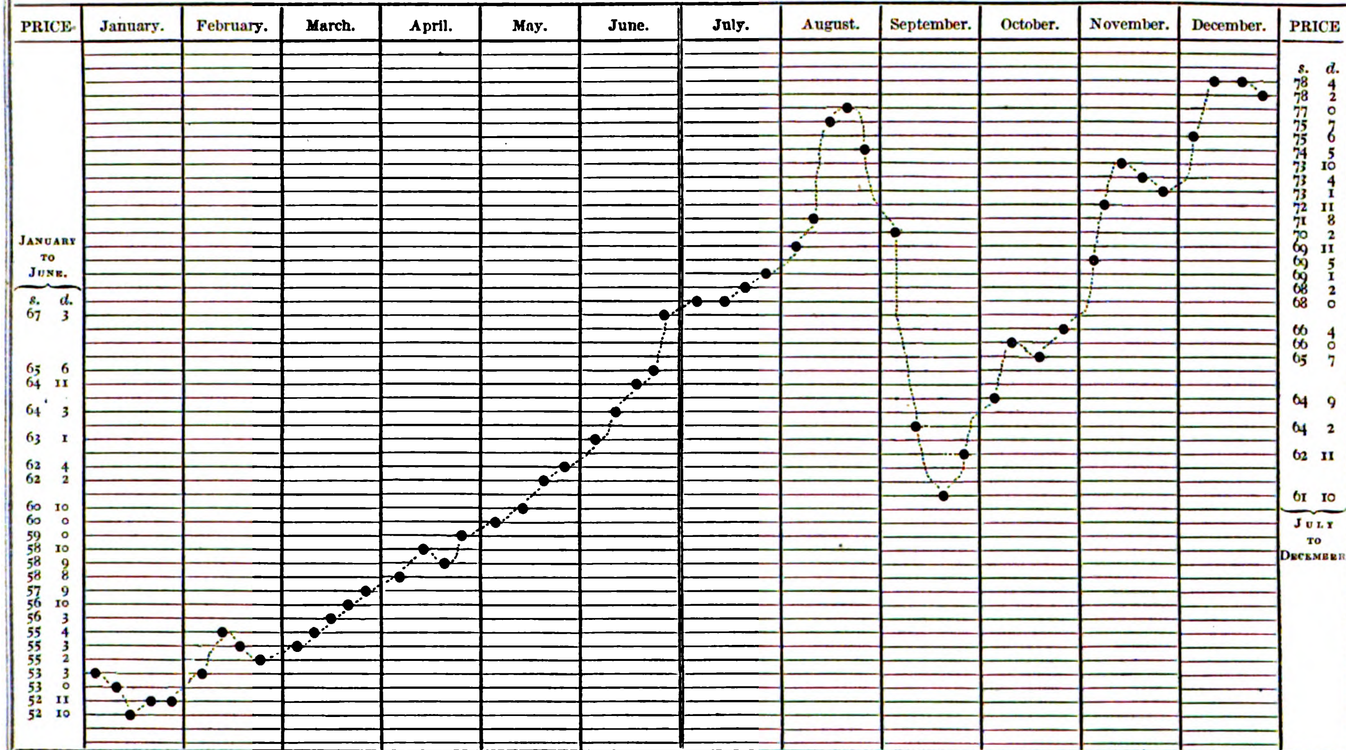


	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	48/9	33/2	23/1	38/4	37/3	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.



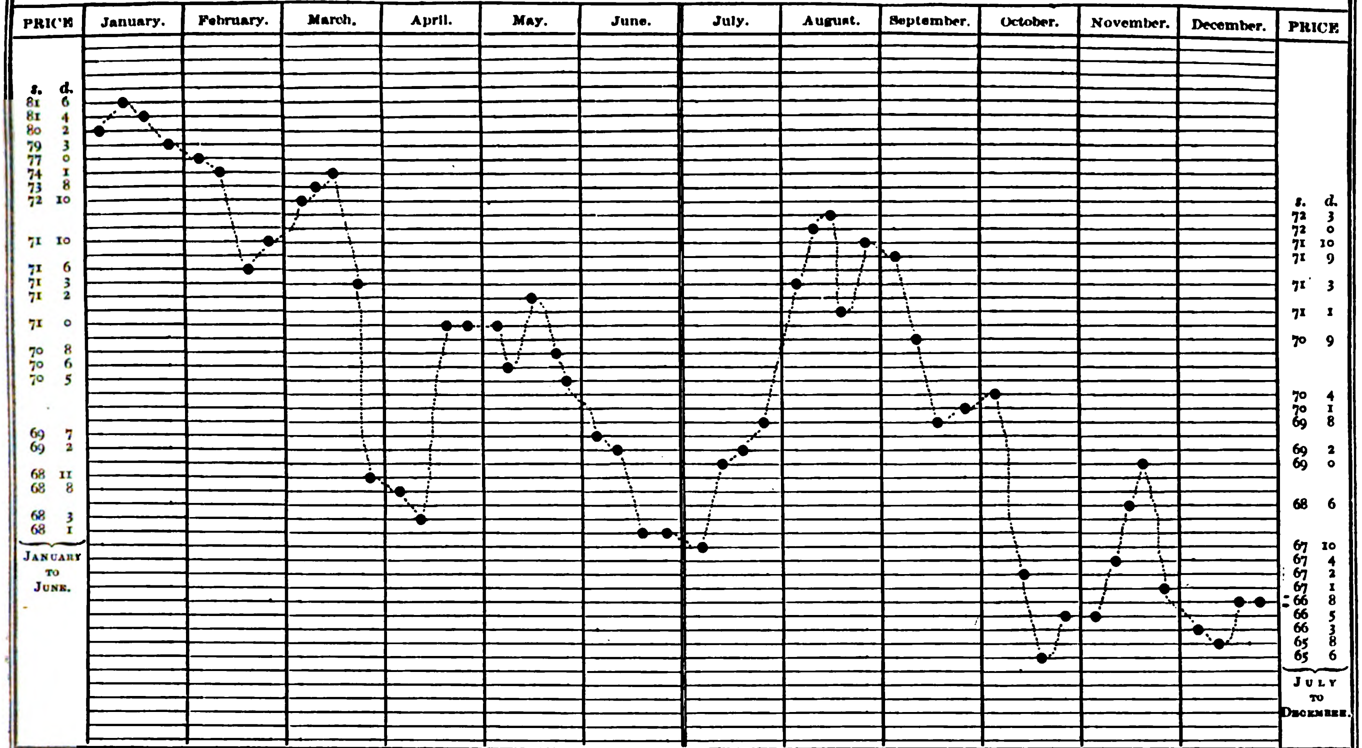
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	55/10	30/4	23/1	38/7	37/9	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.
Import of United Kingdom .	452,369	87,791	413,710	105,671	111,264	4,026	346,325 3 18

1838.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



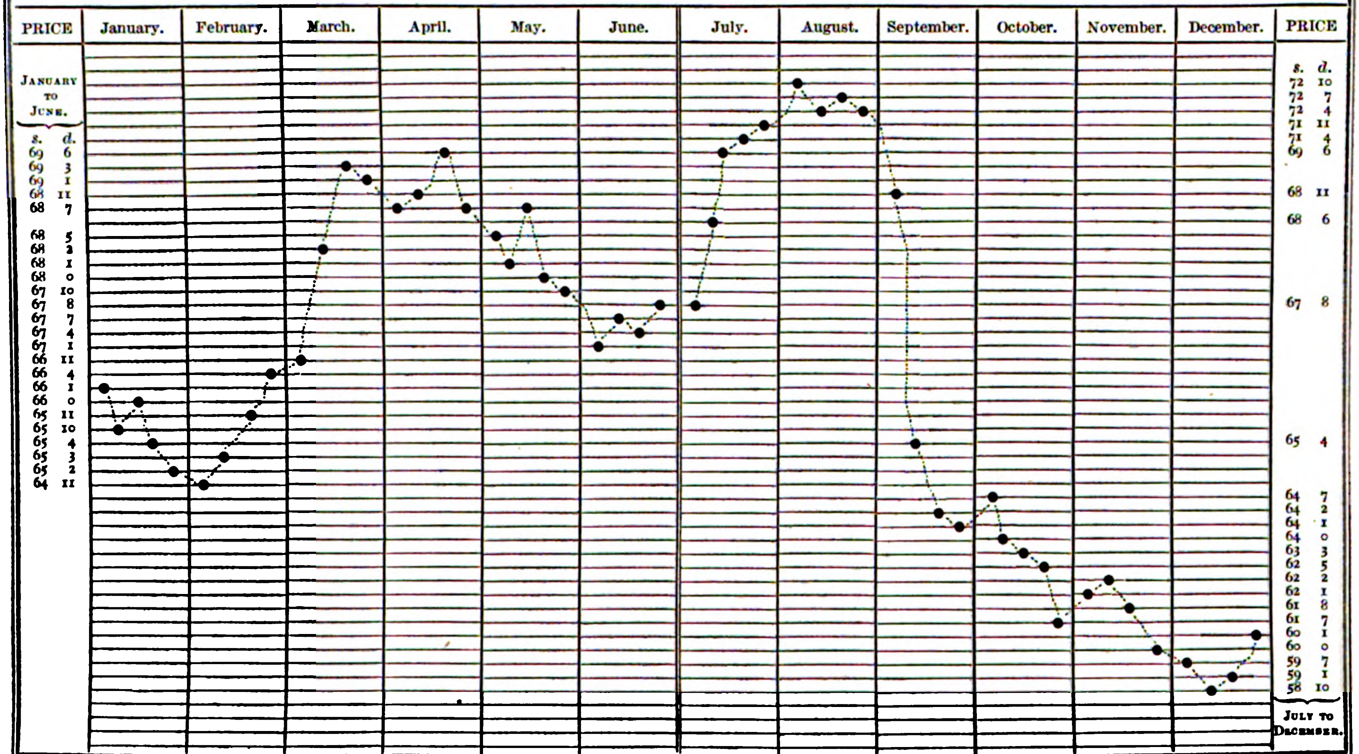
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	64/4	31/5	22/5	37/4	36/8	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1839.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



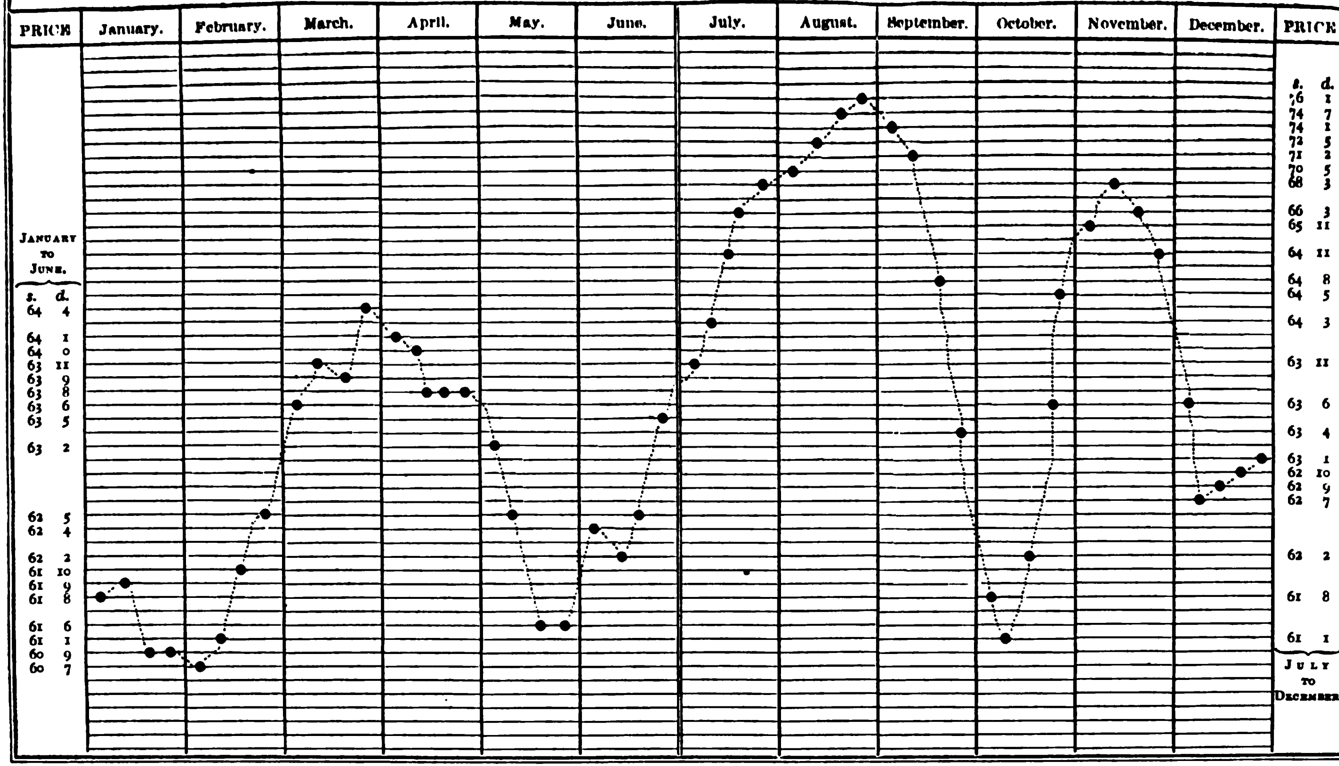
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	70/6	39/1	26/6	41/3	41/1	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts. qrs. lbs.*
Import of United Kingdom .	2,638,593	579,405	674,554	109,810	140,012	9,565	793,606 1 6

1840.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



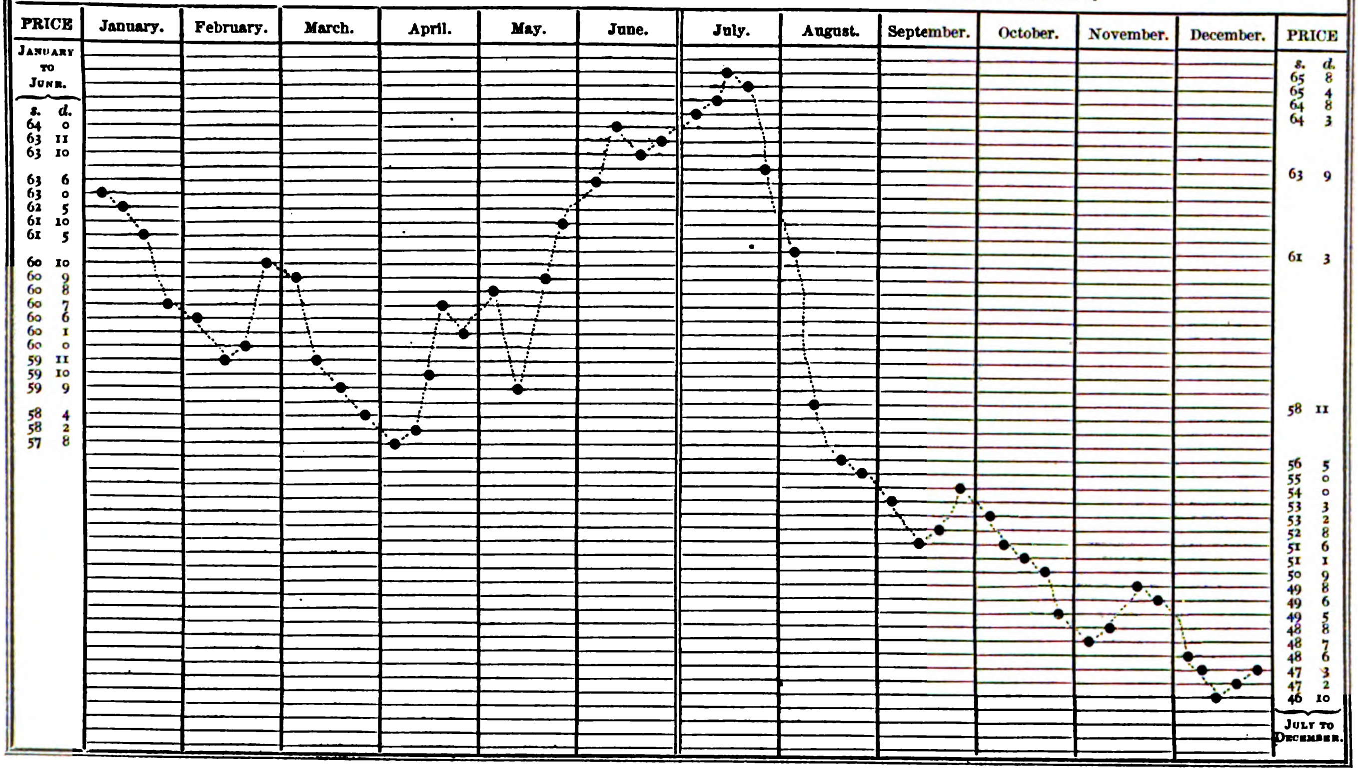
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	66/4	36/3	25/9	43/6	42/5	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1841.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



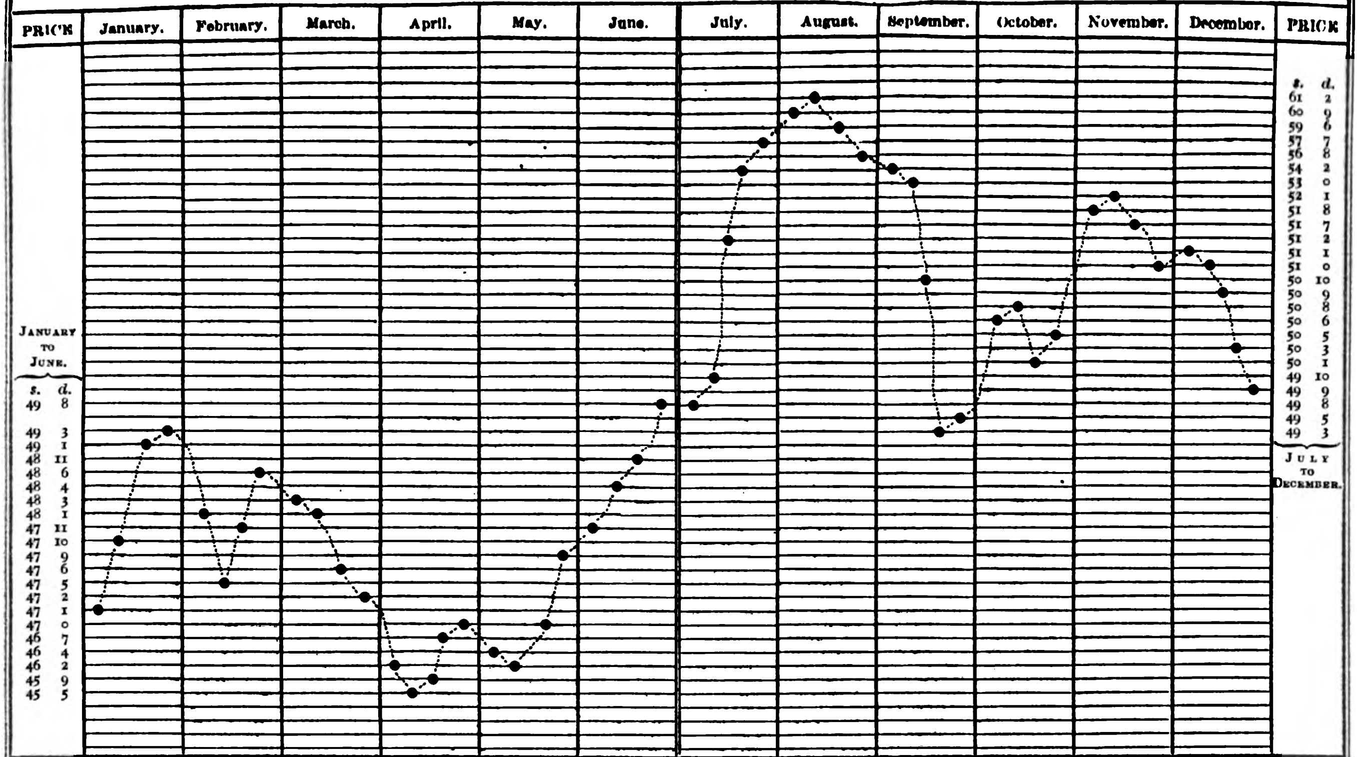
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	64/5	33/0	22/5	40/5	39/1	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts.* *qrs.* *lbs.*
Import of United Kingdom .	2,409,754	264,654	122,297	293,689	148,564	4,137	1,275,656 0 0

1842.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



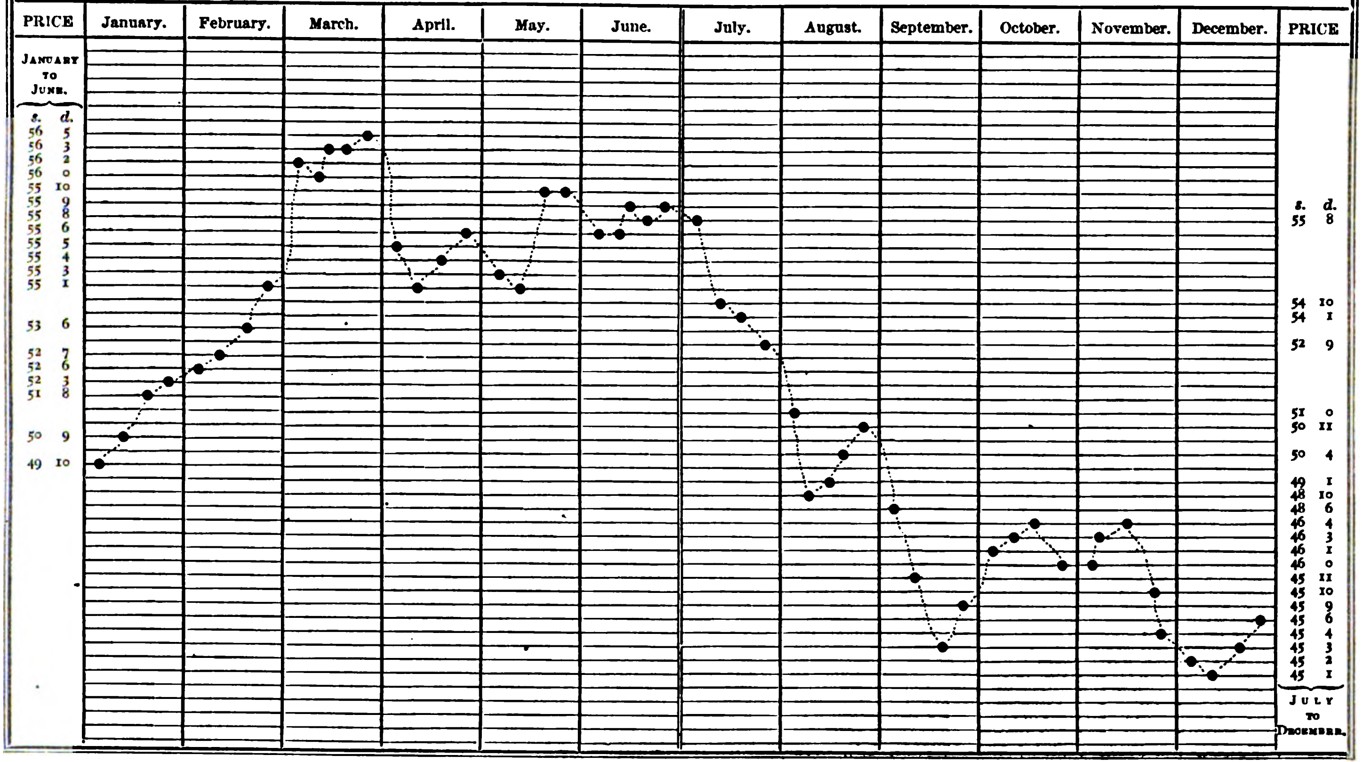
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	57/5	27/6	19/3	32/8	32/11	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1843.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



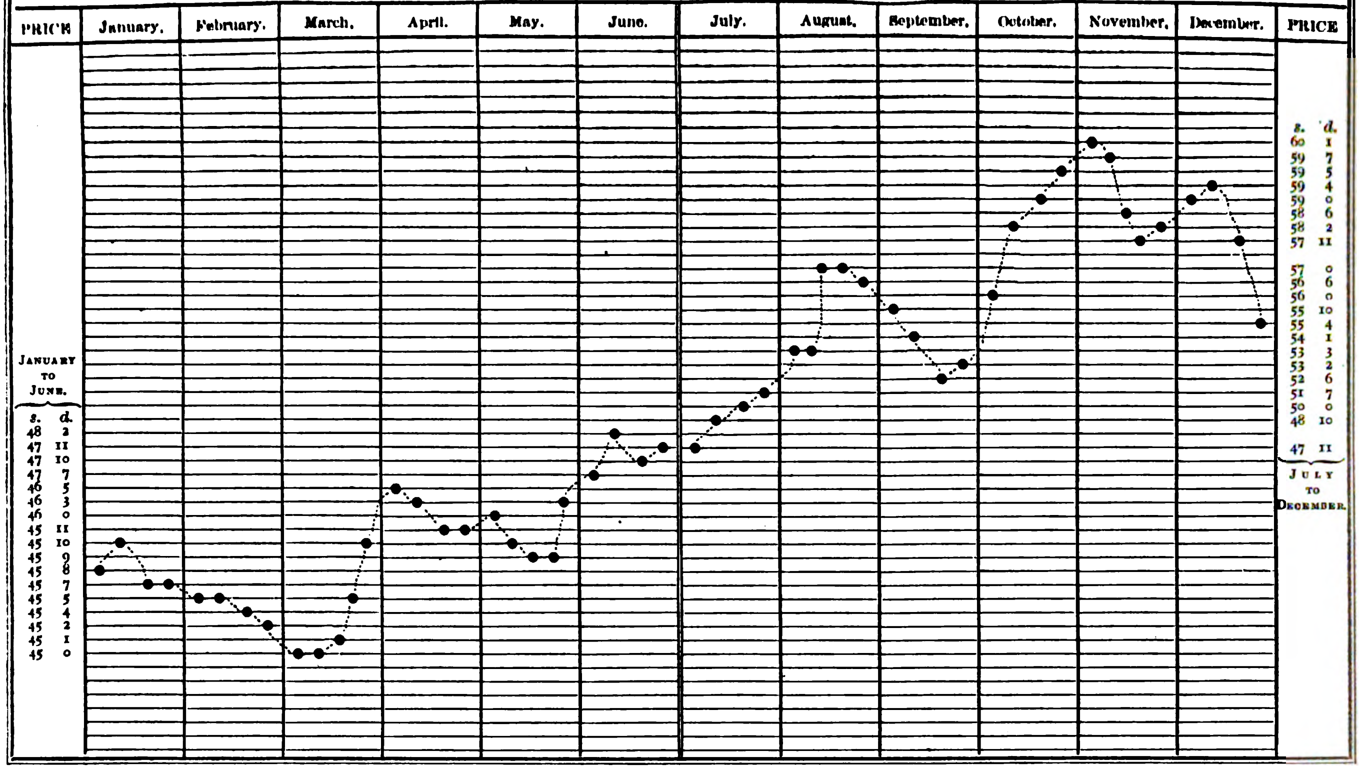
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	50/2	29/5	18/3	29/1	31/1	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts. qrs. lbs.*
Import of United Kingdom .	932,866	179,414	84,718	48,080	48,971	516	440,955 3 23

1844.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



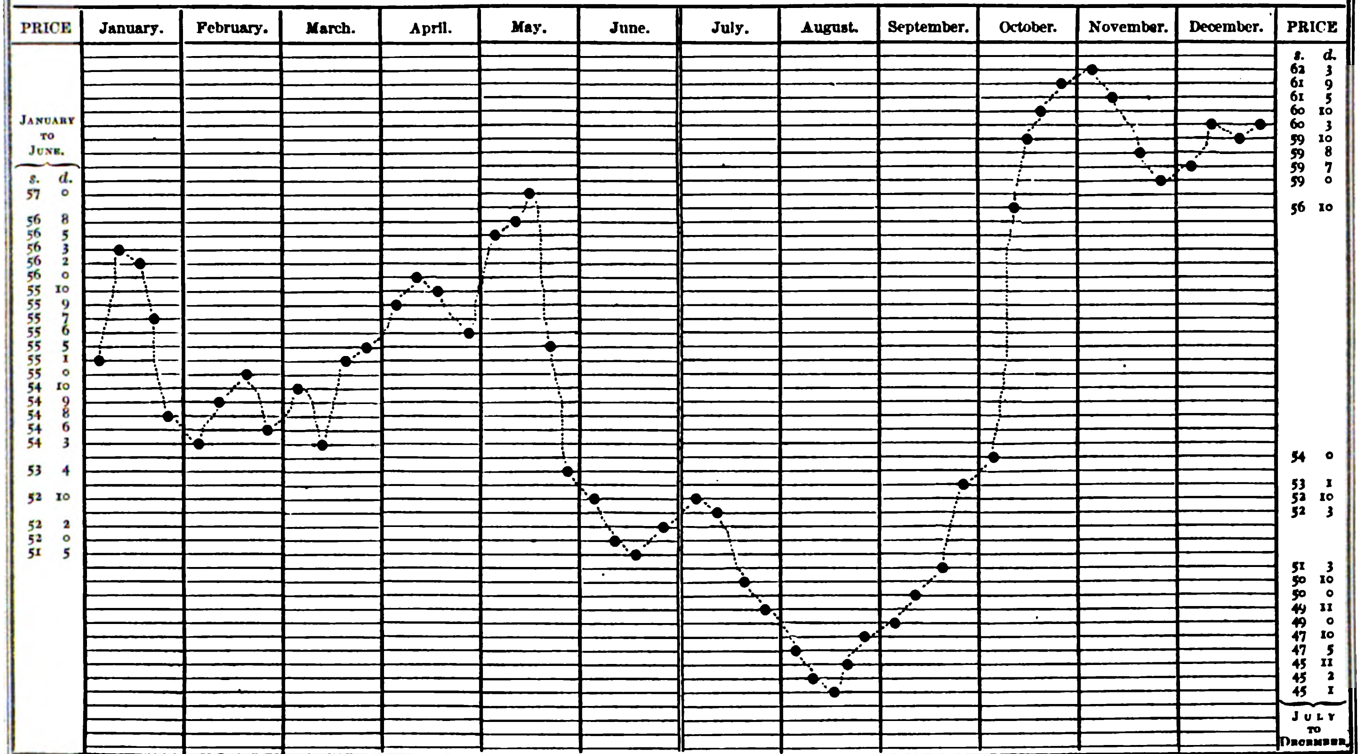
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	51/3	33/7	20/7	34/6	33/5	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1845.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



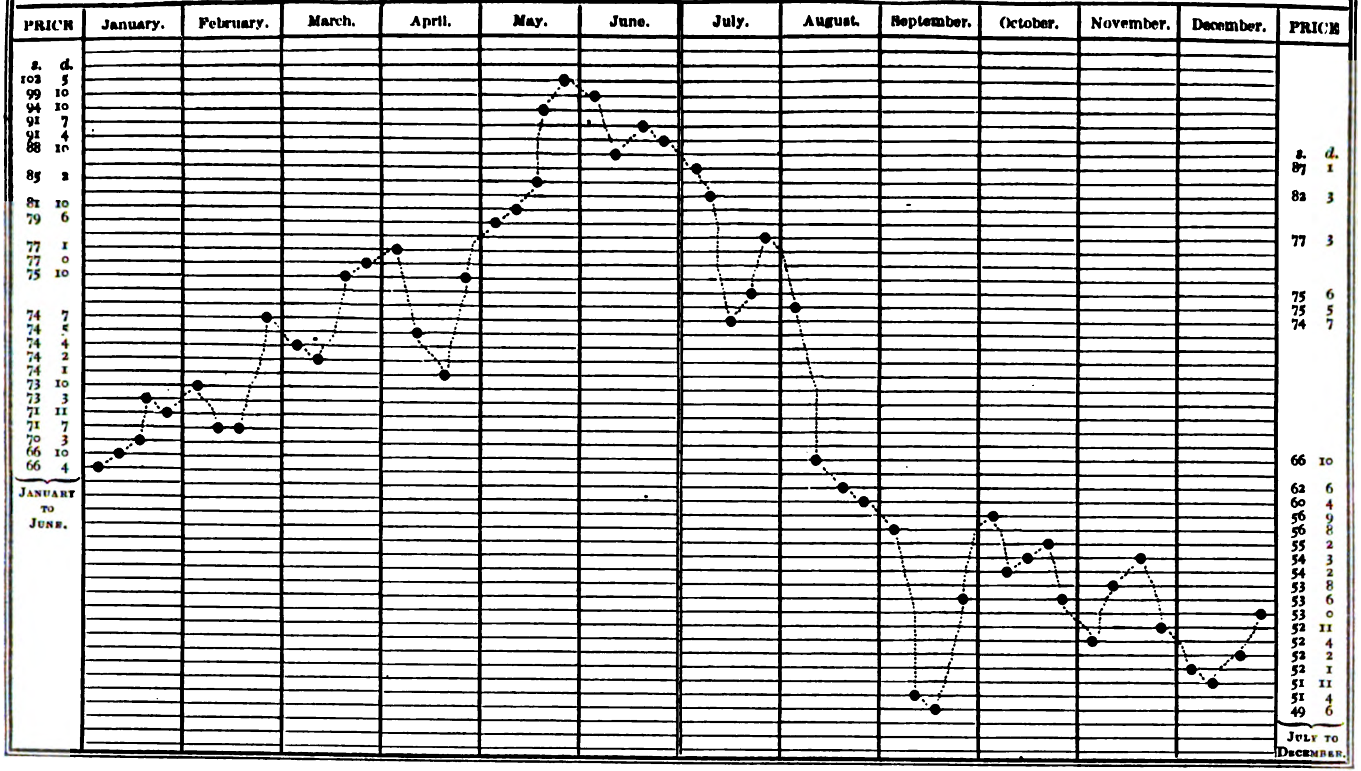
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	50/9	31/8	22/6	39/0	38/6	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts. qrs. lbs.*
Import of United Kingdom .	844,533	367,854	586,860	185,008	80,613	55,984	924,256 2 26

1846.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.



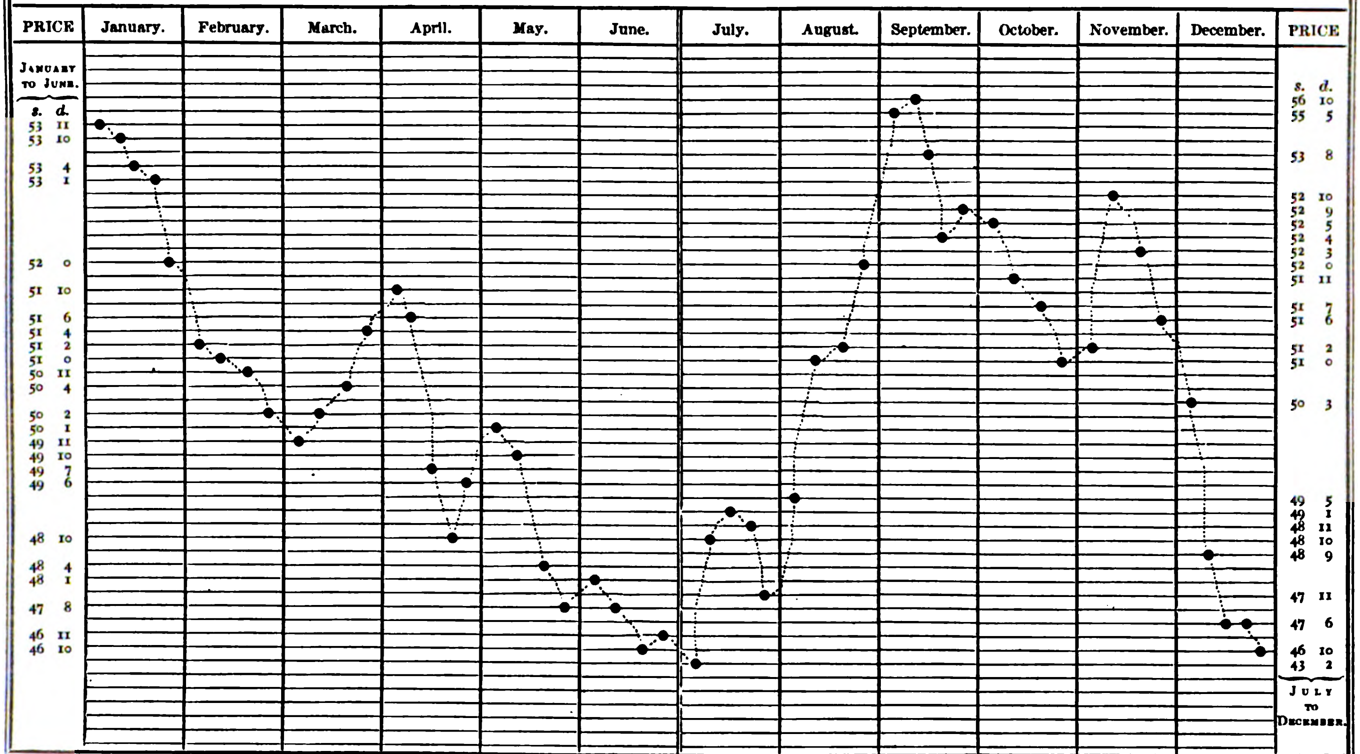
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	54/9	32/9	23/8	39/0	39/0	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1847.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.

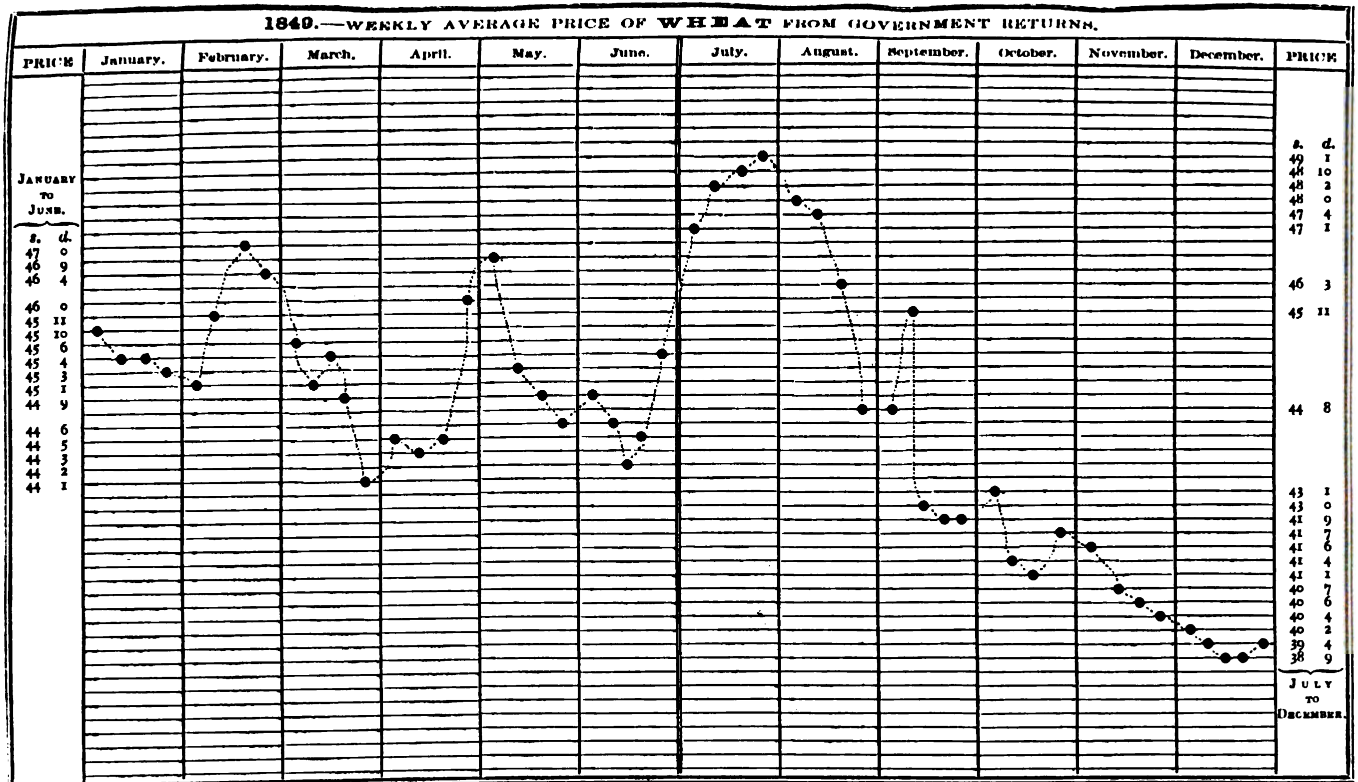


	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	69/5	43/11	28/7	50/1	51/5	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.
Import of United Kingdom .	2,650,058	772,840	1,706,780	443,719	157,245	3,614,637	8,637,377 1 9

1848.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.

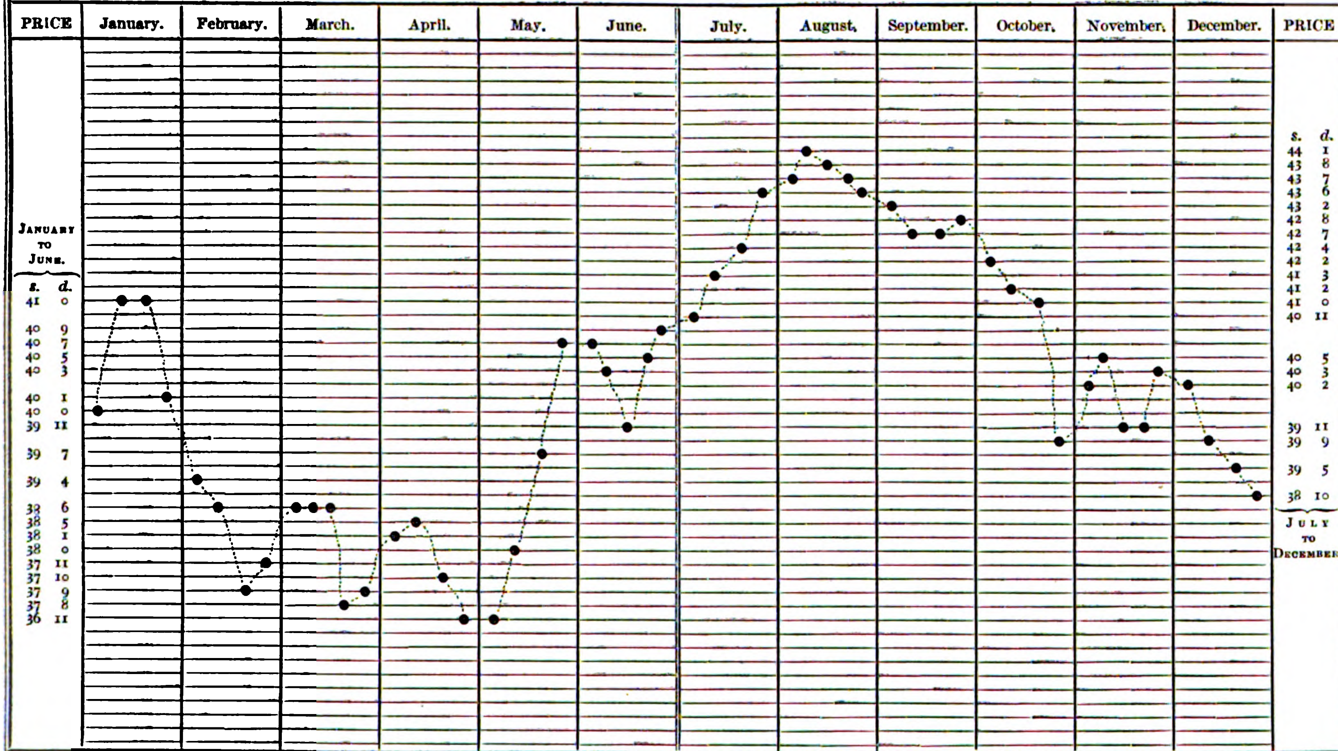


	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	50/6	31/6	20/6	36/9	39/1	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.



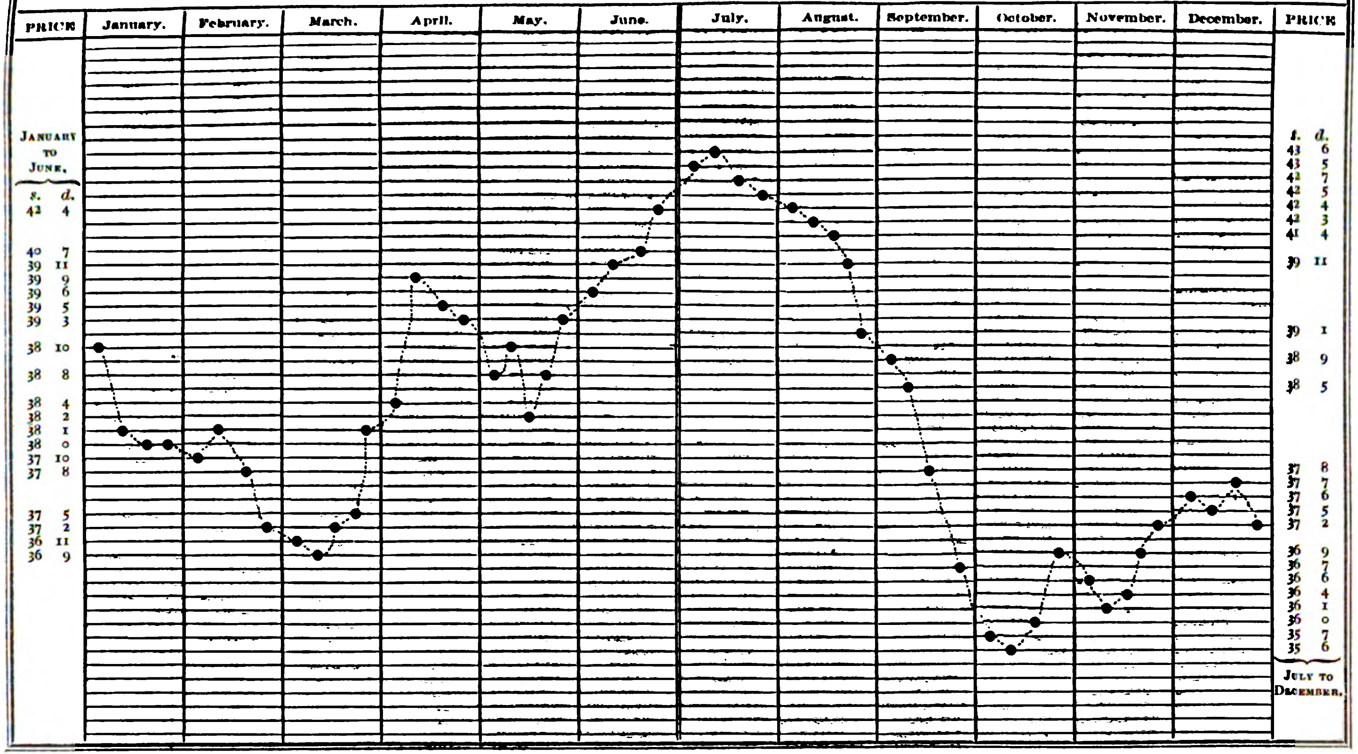
	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	44/6	27/9	17/6	30/3	31/3	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts.* *qrs.* *lbs.*
Import of United Kingdom .	3,872,568	1,388,494	1,281,517	456,023	236,067	2,189,164	3,483,294 0 0

1850.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.



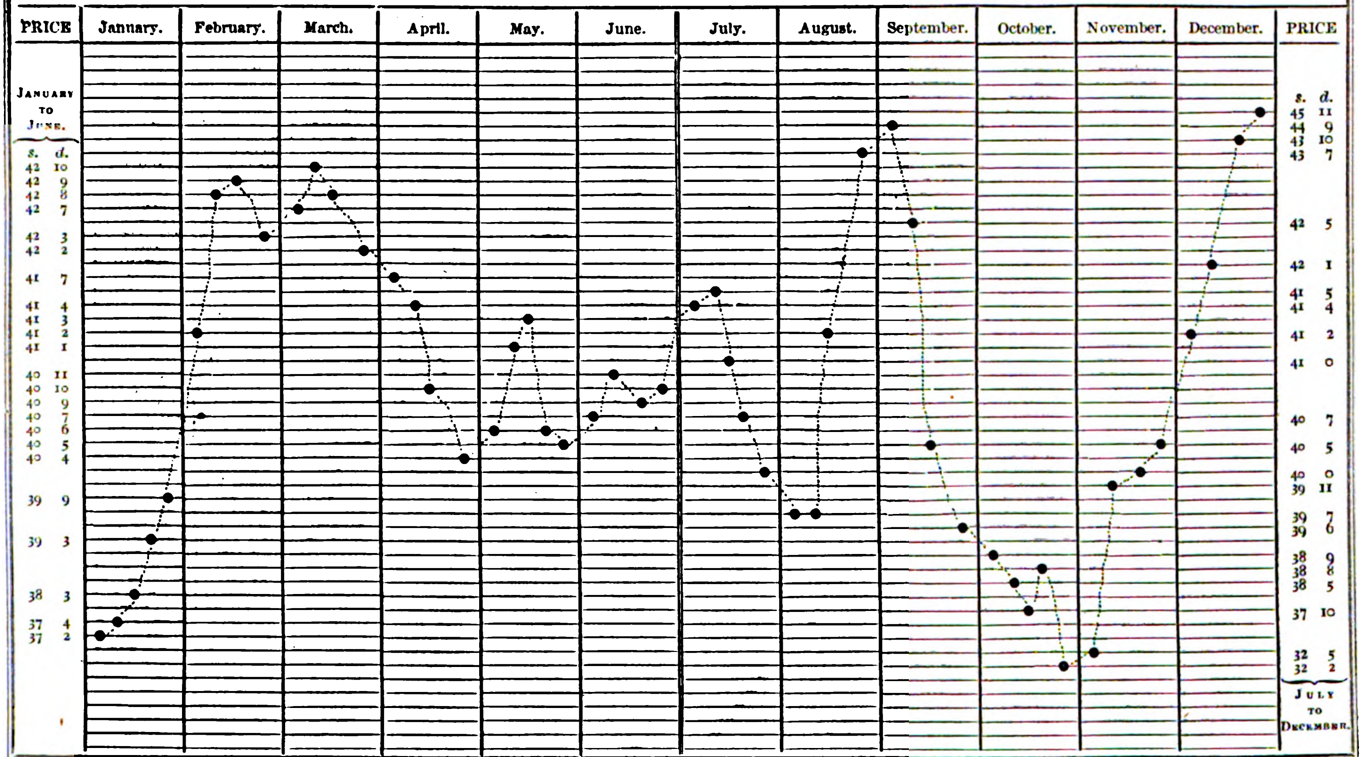
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	40/4	23/5	16/5	26/11	27/5	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.

1851.—WEEKLY AVERAGE PRICE OF WHEAT FROM GOVERNMENT RETURNS.

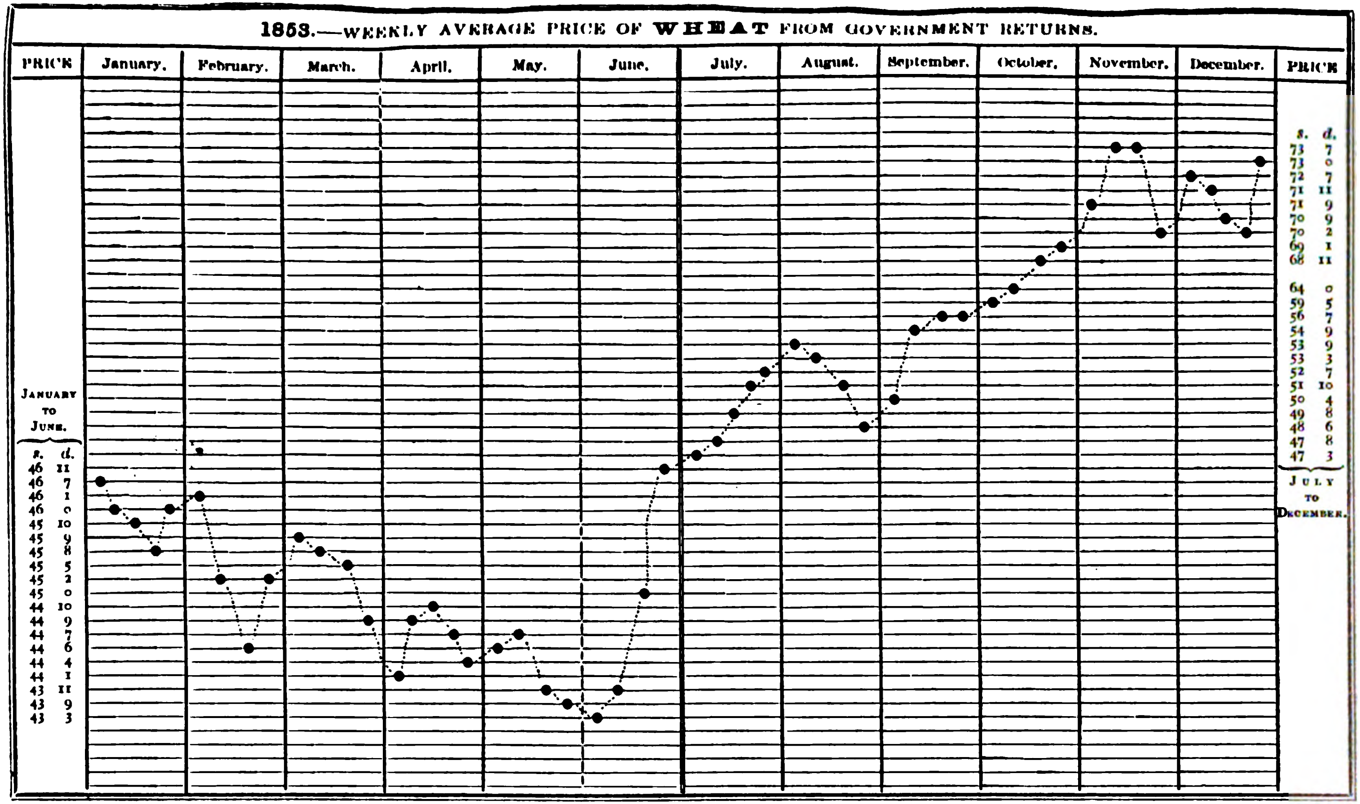


	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	38/7	24/9	18/7	28/9	27/3	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lbs.
Import of United Kingdom .	3,831,836	834,491	1,209,844	318,502	100,392	1,821,573	5,363,478 1 26

1852.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.

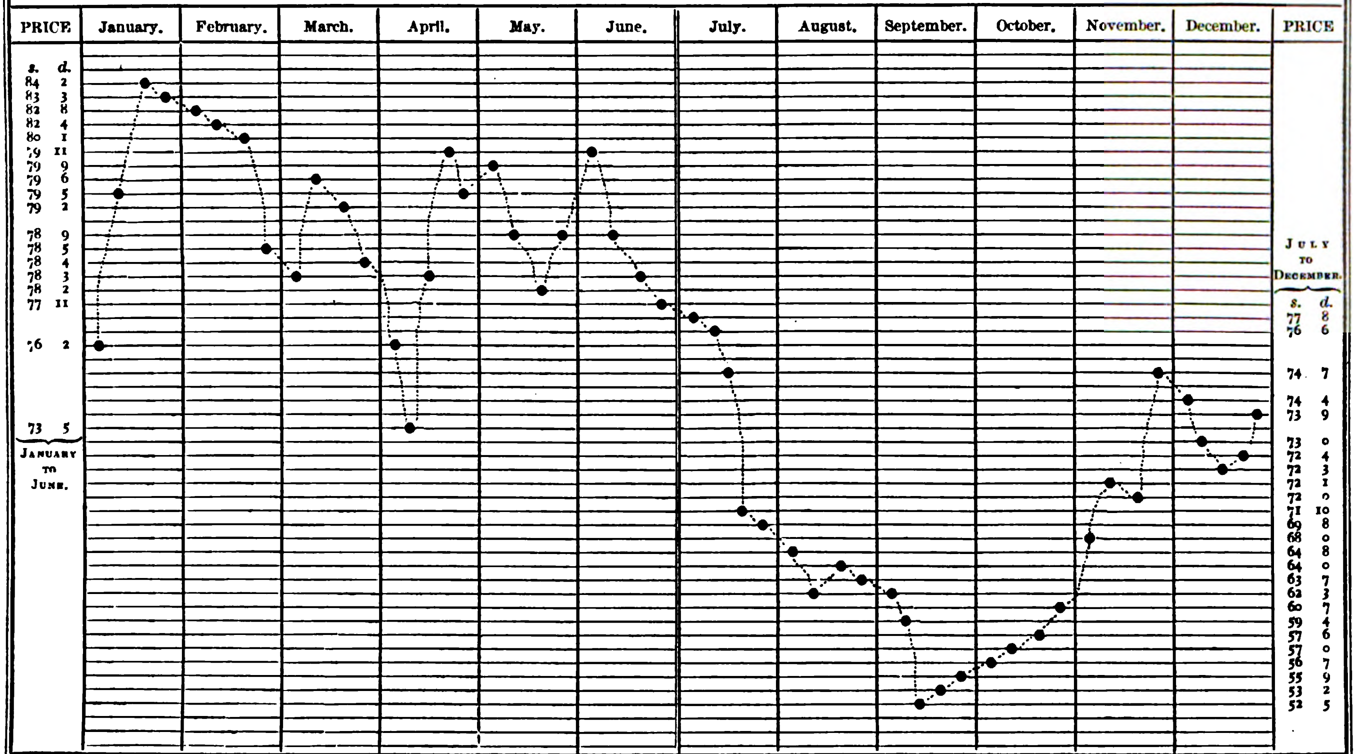


	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.		
Average of Year	41/0	28/7	19/1	32/4	30/8	..	..		
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts.	qrs.	lbs.



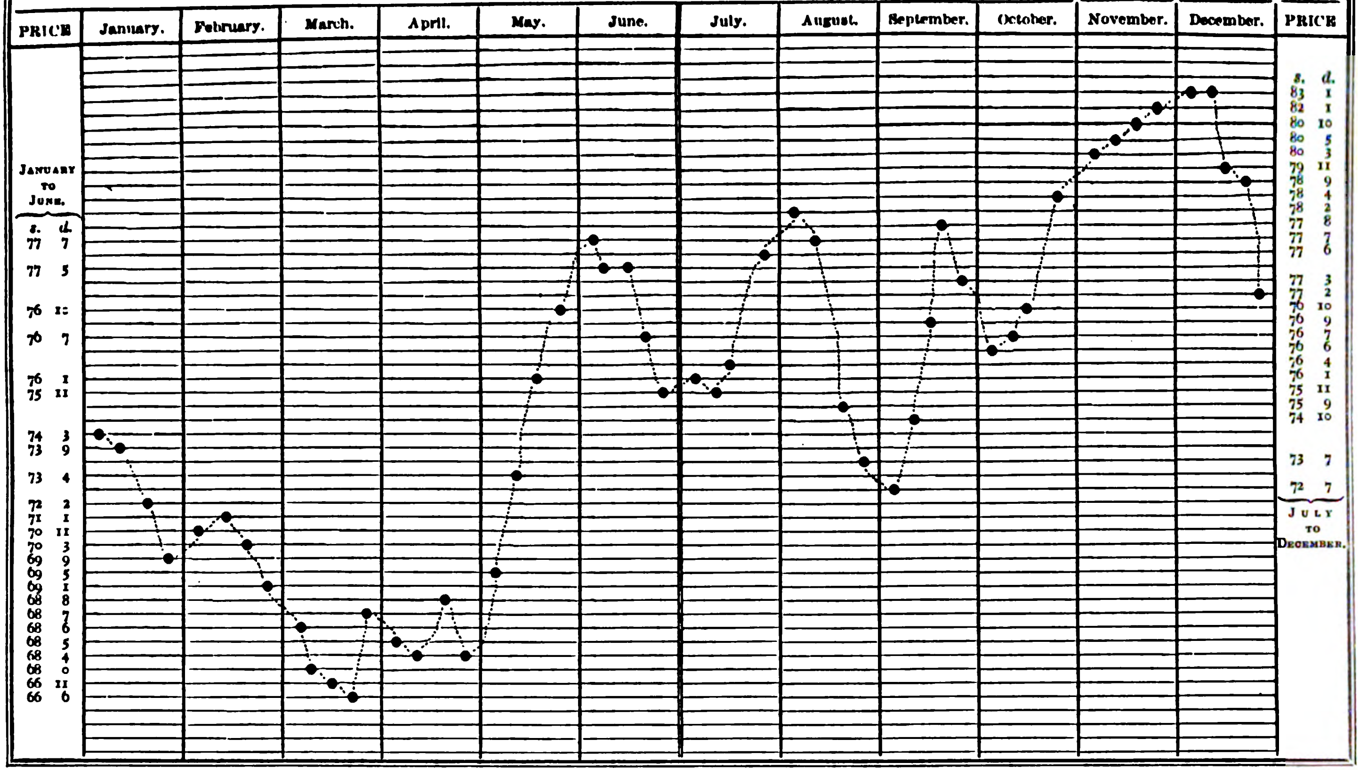
	Wheat.	Barley.	Oats.	Beans.	Peas.	Maize.	Flour and Meal.
Average of Year	53/3	33/2	21/0	40/1	38/6	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts.* *qrs.* *lbs.*
Import of United Kingdom .	4,915,430	824,068	1,028,409	349,596	101,058	1,544,483	4,638,010 0 0

1854.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.

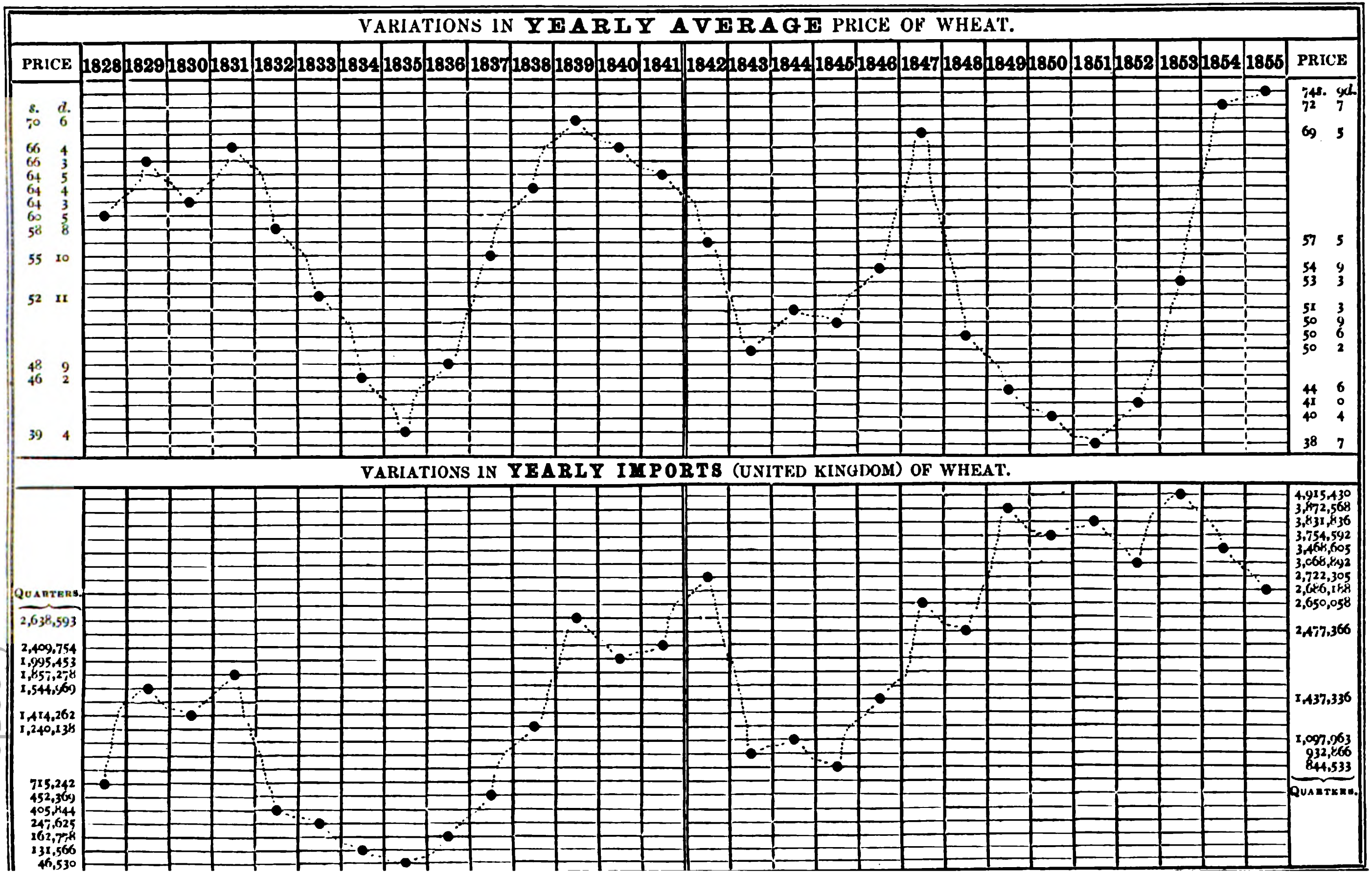


	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	72/7	36/2	27/11	47/4	45/11	..	..
	qrs.	qrs.	qrs.	qrs.	qrs.	qrs.	cwts. qrs. lls.

1855.—WEEKLY AVERAGE PRICE OF **WHEAT** FROM GOVERNMENT RETURNS.



	WHEAT.	BARLEY.	OATS.	BEANS.	PEAS.	MAIZE.	FLOUR AND MEAL.
Average of Year	74/9	34/9	27/6	46/4	43/6	..	..
	qrs.	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*qrs.*	*cwts. qrs. lbs.*
Import of United Kingdom .	2,686,188	354,088	1,044,192	347,451	115,931	1,224,281	1,940,237 2 7


VARIATIONS IN YEARLY AVERAGE PRICE OF WHEAT.
PRICE
1828 1829 1830 1831 1832 1833 1834 1835 1836 1837 1838 1839 1840 1841 1842 1843 1844 1845 1846 1847 1848 1849 1850 1851 1852 1853 1854 1855
PRICE
s. d.
70 6
66 4
66 3
64 5
64 4
64 3
60 5
58 8
55 10
52 11
48 9
46 2
39 4
74s. 9d.
72 7
69 5
57 5
54 9
53 3
51 3
50 9
50 6
50 2
44 6
41 0
40 4
38 7
VARIATIONS IN YEARLY IMPORTS (UNITED KINGDOM) OF WHEAT.
QUARTERS.
2,638,593
2,409,754
1,995,453
1,857,278
1,544,969
1,414,262
1,240,138
715,242
452,369
405,844
247,625
162,778
131,566
46,530
4,915,430
3,872,568
3,831,836
3,754,592
3,468,605
3,068,892
2,722,305
2,686,188
2,650,058
2,477,366
1,437,336
1,097,963
932,866
844,533
QUARTERS.

II.—*Report on the Agricultural Department of the Paris Exhibition.* By J. EVELYN DENISON, M.P., Vice-President of the Jury for Class III. Agriculture.

To the Right Hon. the Lord STANLEY of ALDERLEY, President of the Board of Trade, &c.

MY LORD,—The International Jury of Agriculture (Class III.) of the Paris Exhibition consisted of,—

Count de Gasparin, President ..	.. France.
Evelyn Denison, Vice-President	.. England.
Count Hervé de Kergorlay, Secretary	France.
Boussingault	.. France.
Barral	.. France.
Yvart	.. France.
Dailly	.. France.
Vilmorin (Louis)	.. France.
Monny de Mornay	.. France.
Robinet	.. France.
Delehaye	.. Belgium.
De Mathelin (Léopold)	.. Belgium.
Ramon de la Sagra	.. Spain.
Dietz	.. Grand Duchy of Baden.
Baron de Riese Stallbourg ..	.. Austria.
Dr. Arenstein	.. Austria.
Baron Delong	.. Denmark.
Wilson, J.	.. England.
Amos, C. E.	.. England.
Nathorst, J. T.	.. Sweden and Norway.

It was quite time that France and England should be better known to each other, and that it should be made apparent what great benefits would accrue to both countries from an improved acquaintance and extended intercourse.

Up to the year 1851, till the time of the Exhibition of London, we are told by a French writer of high authority,* "that in France, more perhaps than elsewhere, notwithstanding our near

* M. Leonce de Lavergne, author of 'Essai sur l'Economie Rurale de l'Angleterre, de l'Ecosse, et d'Irlande.' This essay formed part of a course of lectures delivered at the Institut National Agronomique. The information it contains, as regards the condition and prospects of agriculture in these islands, is so correct, and exhibits such a thorough knowledge of the subject in all its branches, that it is a reasonable assumption, that an author who writes so accurately about the affairs of a foreign country may be relied upon when treating of his own. This essay has gone through two editions in France, has been translated into English, and has undergone the ordeal of Scotch criticism.

proximity, an opinion had prevailed that in England agriculture had been neglected in favour of trade and commerce. The tariff regulations of Sir R. Peel, not well understood in their design or in their consequences, had tended to fortify this assumption. Nothing, therefore, created more surprise than the vast collection of agricultural implements which the Exhibition of London contained, and the proof they afforded of the high development of agricultural skill and science in the United Kingdom."

It has been reserved for the Paris Exhibition of 1855 to give new force to these impressions; to carry into the heart of France, and to display before the eyes of hundreds of thousands of spectators, these evidences of the skill of our machine-makers, placed in immediate contrast with the works of their competitors from all quarters of the world.

The approach between the two nations, which was invited by the Exhibition of 1851, has been advanced and quickened by the Exhibition of 1855. The cordial and friendly reception given to Englishmen of all classes in Paris has been thoroughly appreciated and responded to—new interests have been called into action. The advantages to be derived by both people from a more free communication have forced themselves upon public attention, and have taken root in public opinion. Such a result alone would be worth all the labour and all the cost of both Exhibitions.

It was not till the 25th of October, shortly before the close of the Exhibition, that I was made acquainted with your Lordship's wish, that I should furnish a report on the Class of Agriculture. If I had known this wish at an earlier period, some matters, especially matters of detail, might have been noted, which it would not be easy now to go back upon. But I bear in mind that this is not a report, accompanying and justifying an adjudication of prizes. Such a report will be furnished to the Imperial Commission by officers specially appointed in each class, and will be accessible to all.

The terms of the letter addressed to me by your Lordship's directions are, "That I would furnish a report, to be laid before Parliament, of the position which the United Kingdom held in the Paris Exhibition, compared with foreign countries, in the Class of Agriculture, and the progress, if any, which has been made since 1851 in respect of this class of objects."

I propose to follow the course pointed out in this letter of instructions.

It may be well to consider at the outset the position of the two countries as regards agricultural practice at the present moment. Such a picture, full of life and interest, has been drawn to our hands by the able pen to which I have already referred. As the

comparison is very favourable to this country, I prefer to employ the words of a French author rather than to make use of my own.

In natural gifts of soil and of climate the advantages are beyond all question on the side of France. It may be that France has relied too much on these excellent gifts, while England, less favoured, has been urged by her necessities to increased exertions.

SYSTEMS OF CULTIVATION.

"France has devoted herself too exclusively to the production of corn crops, which are the immediate food of man, without sufficiently considering the means necessary to uphold the fertility of the soil under this exhausting process. England, on the contrary, has been led, partly by the nature of the climate, partly by design, to take a sort of by-path, which reaches corn crops through the intervention of green crops; finding, in the rearing of cattle and the supply of manure, the restorative process which is necessary.

"The experiment has entirely succeeded, and is extending itself day by day; and the remarkable fact is, that in proportion as the head of cattle increases the quantity of corn increases also; the gain in intensity exceeds the loss in extent. Thus, on a surface of 31,000,000 of hectares, reduced to 20,000,000 by the waste lands, the British isles produce more food for animals than the entire surface of France, of double the extent.* Hence the supply of manure is in proportion three or four times greater. The average produce per hectare in France is 6 hectolitres of wheat, about 5 of rye, and 1 of maize or buckwheat; collectively about 11 hectolitres. In England, 25 hectolitres of wheat (3½ quarters per acre), more than double in quantity, and three times more in saleable value. Scotland and Ireland are included in this estimate. If the comparison is made with England alone, the results are far more striking. This little country, not larger than one-fourth of France, produces 38,000,000 of hectolitres of wheat, 16,000,000 of barley, 34,000,000 of oats. If France produced as much in proportion, she would produce, deducting seed, 150,000,000 hectolitres of wheat, 200,000,000 of oats and other grains; that is, at least double her actual production.

"Taking all products into account, animal and vegetable, it appears that the produce of England, per hectare, nearly doubles that of France.

"The great lesson which these figures teach, beyond the disproportion of the results, is the relation of vegetable to animal

* I preserve the French measures, together with the calculations of the author. The French hectare is equal to 2·471 English acres.

products. In France the vegetable products form four-sixths of the whole, and the animal products two-sixths only; showing at first sight an exhausting cultivation, and one at least stationary. In the United Kingdom the animal products are equal to the vegetable. Thus the animal products alone of an English farm are equal to the entire products, animal and vegetable, of a French farm of the same extent.

Sheep.

"The most remarkable feature of British farming, in comparison with that of France, is the number and quality of the sheep. According to the statistical returns and estimates, the number of sheep in France and in England is about equal, about 35,000,000 of sheep in France and 35,000,000 in England. But this apparent equality conceals an inequality the most marked. 35,000,000 of sheep in the United Kingdom live on 31,000,000 hectares of land. 35,000,000 of sheep in France live on 53,000,000 hectares. France, in order to have as many sheep in proportion as the United Kingdom, ought to have 60,000,000. If the comparison is made with England alone, the difference is far greater. England feeds 30,000,000 of sheep on 15,000,000 hectares of land; that is, proportionally, three times as many as France.

"But the great difference is in the quality of the sheep, upon the breeding and improving of which, with a view to weight and early maturity, so much care and attention has been bestowed. The weight of an English sheep is twice that of a French sheep; so that an English farm on an equal surface gives six times as much mutton as a French farm.

Horned Cattle.

"In the case of cattle, the same care in breeding from selected animals in the United Kingdom, and continually improving the races, in studying meat-producing qualities and early maturity, has effected results similar to the results produced in sheep. France possesses 10,000,000 head of cattle, the United Kingdom 8,000,000. In France, three products are demanded from cattle —labour, milk, and meat: in England only two—milk and meat. The yield of these two valuable productions is materially interfered with by requiring work also from cattle. It might appear, at first sight, that the work of cattle could not in an important degree influence the supply of meat, and it is not difficult for people to persuade themselves that labour in utilising the life of an ox enables meat to be sold at a lower price. But experience has proved, that if this is sometimes a truth in detail, it is an error in the gross.

"The habit of labour forms hardy, vigorous races, which, like

men devoted to hard work, eat much, fatten slowly, develop their bony structure, make little flesh, and make it slowly. The habit of inaction, on the contrary, forms races, gentle, tranquil, which fatten early, assume round and fleshy forms, and give with equal food a far larger yield to the butcher. If we look to labour, the ox is killed when he has finished his task. If we look to meat, the ox is killed at the moment when he yields the largest amount. Cattle in France are killed too young or too old; among the 4,000,000 head killed, figure 2,000,000 calves, giving each only 30 kilogrammes of meat. Those which survive are killed at an age when the growth has long ceased, *i. e.*, when the animal has long been consuming nourishment which has not added to his weight.

"In England, on the contrary, animals are killed neither so young, because in their youth they make the most meat, nor so old, because then they make none. The moment is seized when the animal has reached his maximum of increase.

"In France the number of animals killed annually is about 4,000,000 head, producing 400,000,000 kilogrammes of meat, averaging therefore 100 kilogrammes per head.

"In the United Kingdom the number killed is 2,000,000, producing 500,000,000 kilogrammes of meat, averaging 250 kilogrammes per head.

"Thus, with 8,000,000 head of cattle and 30,000,000 hectares of land, British agriculture produces 500,000,000 kilogrammes of meat; while France, with 10,000,000 head of cattle and 53,000,000 hectares of land, produces only 400,000,000 kilogrammes."

Such a description of the high attainments of English agriculture having been placed before the public of France, it was natural that great expectations should have been formed both as to the display of live stock and the exhibition of agricultural implements. Nor, I venture to say, were these expectations disappointed. The cattle of our improved breeds found a crowd of admirers and many purchasers. The Durham short-horns have been imported largely into France for some years by the agents of the French Government, and very good specimens of this race, bred in France, were exhibited. The first prize, for young bulls of the Durham breed, was awarded to the Marquis de Talhouet, for a bull sixteen months old. More surprise was created by our sheep, especially by the large size and admirable symmetry of our South Downs. The jury decided that a gold medal of the first class should be struck in the name of Mr. Jonas Webb, for the collection of South Down sheep, bred and exhibited by himself. The cattle show took place before the juries for the Palace

of Industry were summoned to Paris; I had not the good fortune myself to see the show. The deputation who accompanied the President of the Royal English Agricultural Society were greatly pleased with the excellent arrangements of the show, and with some of the continental breeds of cattle, especially with the French Charolais race, as very good in themselves, and offering a stock very suitable for crossing with short-horn bulls; also with the Métis-merino sheep, pointing out the road which French breeders must pursue to accomplish the end of their mission—the supply of meat at a reasonable price to the markets of France. Though horses formed no part of the show, I must not omit to mention the race of draught horses, known by the name of Percheron. They are strong, muscular, hardy horses, of great power and activity, worthy the attention of English breeders, better suited for the quickened step of improved farming than the heavier sort of English cart horse.

The collection of agricultural implements was formed by Mr. Brandreth Gibbs, under the direction of the Board of Trade, assisted by a committee of the English Agricultural Society. The selection was made with great judgment; the implements sent were not too numerous, and they were all of established excellence. They consisted of ploughs, harrows, cultivators, broadshares, drills, horse-hoes, rakes, rollers, reaping machines, haymakers, &c., portable steam-engines, threshing-machines, chaff-cutters, corn-crushers, and machines for making draining tiles. But the French system of classification placed in the list of agricultural implements those implements only which are used in the fields. It removed the articles last on the list—threshing-machines, chaff-cutters, corn-crushers, machines for making draining tiles—from the jury of agriculture, and placed them in Class VI., "Mécanique spéciale." This led to some practical inconvenience in the conduct of the trials, and to a seeming inconsistency connected with the change made in the tariff of duties, of which I shall presently speak.

The first trial of implements took place on the 7th of July, at Trappes, about ten miles beyond Versailles, on the farm of M. Dailly, a member of the jury, who afforded every possible accommodation and the most liberal hospitality both to the exhibitors and the members of the jury.

The day was chiefly devoted to the trial of ploughs; an English hay-maker was exhibited, and tried on newly-mown lucern. In England it is employed generally only for meadow grass, for which it is best suited. Though a machine of very long standing in this country, it appeared to be a novelty in France, and was much admired and approved.

Subjoined is the report of the experiment on ploughs, furnished by Mr. Amos, my colleague, consulting engineer of the English Agricultural Society, who assisted at the trials.

TRIALS OF PLOUGHS.

Trappes, July 7th, 1855.

Fifteen were used from various countries. A great difficulty was experienced in obtaining the names and addresses of the exhibitors, through the cards or marks not being placed on them. This accounts for the imperfection of the first column, viz., "Makers' Names."

The land was light, and offered but little resistance to well-made ploughs, but the experiments would have been more valuable had more "field room" been given, so that each plough could have made three or four turns before the dynamometer was applied. Each plough should also have worked to *the same depth*, as the ground was harder at bottom.

The "ground" is also usually harder near the old "water furrow," and lighter near the old "ridge;" hence each plough should have had a "land" or "ridge" to itself, and then, had the dynamometer been applied at an equal distance from the old "furrow," greater truth would have been obtained.

The dynamometers tried were one provided by the French, one from Denmark, and one from England (by Bentall). The latter was used, but it is imperfect when used with ploughs of "light draught," as it gives the "resistance" of such ploughs too small. This arises from the driving "disc-plate" having a hole in its centre; and although that hole is of no consequence or inconvenience when ploughs are used on "heavy land," yet when used with ploughs of small resistance on "light lands," the spring of the dynamometer is not compressed enough to keep the "driving-disc" clear of the hole; hence the "registration" is too small with light ploughs. This may account in some degree for the difference (*as recorded*) in the draught of the ploughs of our best makers.

The following table gives the length, breadth, and depth of "earth removed," which, being multiplied together, gives a "total" in cubic feet. The tabular number in the seventh column is the number recorded by the dynamometer. This number in each case multiplied by 100, and the product divided by the number of cubic feet of earth removed in each experiment, gives the tabular numbers in the eighth column. The numbers in the eighth column show the "*comparative cost*" or "*expenditure of power*" of removing an equal quantity of land, the *lower number* showing the *greater degree of excellence* of the implement.

EXPERIMENTS ON PLOUGHS AT TRAPPE, NEAR VERSAILLES. July 7th, 1855.

No. of Trial.	1. Maker's Name.	2. Country.	3. Mean Breadth.		4. Mean Depth.		5. Length in Feet.	6. Quantity of Earth in Cubic Feet.	7. Dynamometer.	8. Comparative Resistance.	9. REMARKS.
			Centimes.	In.	Centimes.	In.					
1	Florian Maurer . .	Duchy of Baden	·25	9·84	·16	6·20	1,444	611	..	..	..
2	Busby	England . .	·25	9·84	·17	6·70	1,444	661	42	6·3	Made excellent work.
3	Barrosch and Jasper .	Austria . .	·27	10·63	·175	6·90	1,444	735	..	..	Called the "Geometrical Plough." This was so badly managed, and its coulter arrangements so imperfect, that the experiment could not be finished.
4	Berckman . . .	Belgium . .	·23	9·00	·17	6·70	1,444	604	43	7·1	Rough work.
5	The "Brie" Plough .	...	·28	11·00	·12	4·74	1,444	522	..	..	Furrow not well turned.
6	The "Toronto" . .	Canada . . .	·20	7·87	·19	7·48	1,444	590	45·5	7·7	Worked very well.
7	The "Grignon" . .	...	·25	9·84	·17	6·70	1,444	661	29	4·4	Good work.
8	Jos. Tixon	Belgium . .	·25	9·84	·18	7·10	1,444	700	42	6·0	The land side left extremely rough.
9	Howard	England .	·23	9·00	·175	6·90	1,444	622	16	2·6	Very good. Draught very light.
10	Barrosch and Jasper .	Austria . .	·25	9·84	·16	6·20	1,444	611	62	10·1	Without a coulter; the mould board set very obtuse, and the land side very rough. Called the "Ruchadlo."
11	Ball	England . .	·22	8·66	·19	7·48	1,444	630	22·5	3·4	Very good.
12	The "Thaer" Plough.	Saxony . . .	·24	9·44	·18	7·10	1,805	840	·136	16·2	Mould board set very obtuse, causing an excessive resistance.
13	Ransome and May .	England . .	·23	9·00	·18	7·10	1,805	801	50	6·2	Work very well done, land rather harder.
14	J. M. Odeurs . . .	Belgium . .	·26	10·23	·165	6·50	1,805	833	57	6·8	Worked well, the land well turned over and pulverised.
15	The "Toronto" Iron Plough.	Canada . . .	·22	8·66	·20	7·87	1,805	854	72	8·4	Very good.

C. E. A.

In carrying out the details of the experiments, the able assistance rendered me by Mr. Edward Combes, C.E., of Paris (a gentleman recommended by Professor Wilson), was eminently useful. C. E. AMOS.

The trials, for the reasons above mentioned, could not be considered entirely complete or satisfactory. The indications of the dynamometer were unduly favourable to the ploughs of the lightest draught; but making the fullest allowance for this, the difference between the resistance offered by the different ploughs will appear very remarkable.

The best French plough, the "Grignon," was light, cheap, simple in construction, and did very good work; but in comparison with Howard's plough, the dynamometer marked 29 as against 16; in comparison with the best Belgian plough, "Odeurs," 57 as against 16.*

It was objected against the English ploughs, and indeed against the English machines in general, that they were too heavy and too costly; but the trials showed that a light plough does not always make light work, nor is an implement, cheap at first cost, always the cheapest in the end. The same objections against iron ploughs, and in favour of the old wooden ones, have been freely made at home, but they are passing away under a longer experience. To do good work in the field you must have strong and well-constructed implements. The best implements are the cheapest in the end; they are fast superseding inferior machines at home, and they will no doubt in time obtain the same preference wherever they shall be put fairly to the test.† The value of solidity and strength was fully recognised in the implements akin to ploughs, drags, scarifiers, and broadshares, by which so much of the labour on the best cultivated farms is now effected. The implements by Garrett, Bentall, and Coleman were the first of their class, and their superiority was not contested.

The position of the English exhibitors of agricultural implements was not an encouraging one. They sent specimens of their newest inventions and most approved machinery. These might be examined, copied, purchased as models, by foreign competitors. The individual machines exhibited might indeed be sold at the close of the Exhibition, on the payment of a duty

* Further trials on the 1st and 2nd of August, and on the 14th and 15th of August, made with the dynamometer of General Morin, varied in some degree these results. They were made in the absence of the English makers and their workmen. They were favourable to the light draught of the Grignon plough.

† Howard's plough was bought on the ground for the Government Establishment at Grignon.

of 20 per cent. *ad valorem*. But the sale of a single machine was, of course, a most inadequate compensation for the trouble and expense incident upon the Exhibition; nothing more, however, was in view. The duty on the importation of machinery was so high, that it amounted to a prohibition. It was not to be expected, under such circumstances, that any great zeal or enthusiasm should prevail among the English machine-makers, busy at that moment in preparation for the Carlisle show. Still, when notice was given of the intended trials at Trappes, at a few days' warning only, several of the makers themselves came over, bringing with them their workmen, and they appeared on the ground ready to contend for the honour of victory, though victory should be barren of all but honour. At the close of the day their conduct through the trials drew from Count de Gasparin, the president, these complimentary words:—"Your countrymen have indeed set an example to all. They have brought good implements, men to manage them, an interpreter to speak for them, an engineer to advise with. This is the way in which business should be done."

An international exhibition, which had broken down no barriers of prejudices or partial laws, which had ended without exciting friendly sympathies, or promoting friendly intercourse, would have been but a barren display. The enlightened Frenchmen with whom I had the good fortune to be associated were the first to pronounce in favour of free exchange. Our class agreed unanimously to make a representation to the Imperial Government in favour of a reduction of the duty on foreign agricultural machinery. The representation was successful: an Imperial decree appeared in the *Moniteur* of September 7, making a considerable reduction in the duty on many manufactured articles, and specially reducing the duty on agricultural machinery to 15f. per 100 kilogrammes. This duty being by weight, 15f. per 100 kilogrammes (equal to 2 cwt.) operates unequally in different classes of machinery.

On an iron plough, for instance, in which the weight of the raw material, in comparison to workmanship, is considerable, the duty will be something above 20 per cent. *ad valorem*. In the more complicated machines, into which labour enters more largely, as in drills, horse-hoes, &c., the duty will be from 15 to 20 per cent. *ad valorem*.

This concession was accepted with much satisfaction by our machine-makers; orders to some extent were received for machines. The barrier, at all events, which had hitherto stood between the industry of the two countries was broken down, and ground was laid for a trade which may be ripened and matured into results of mutual benefit to both countries.

I have said that portable steam-engines, and threshing-machines, and tile-making machines were not included in the list of agricultural implements.

Unfortunately the classification in the books of the Custom-house corresponds with the classification in the catalogue of the Exhibition, consequently those machines not falling under the denomination of agricultural machines do not partake of this reduction of duty.

Of all machines connected with agriculture, there are none in which greater improvements have been made in late years than in machines for making pipe tiles for draining. There is no class of machinery which would be more useful in France. The excellent results of draining are there thoroughly understood and appreciated. Specimens of draining were exhibited by the Marquis de Bryas (Gironde) and the Viscount de Rougé (Aisne) from the opposite extremities of France.

The draining of the Medoc vineyards by Count Duchâtel has been attended with complete success. It is computed that one-seventh of the surface of France requires draining. It is understood now that draining not only keeps land drier during the rains of winter, but keeps it cooler and more moist during the heats of summer, preventing the baking of the surface by the sun, and promoting the constant progress of vegetation. It is the foundation of all improvements—the first step in the path of good cultivation. No machines attracted so much attention as the tile machines of Messrs. Clayton and Whitehead, exhibited in work. They were surrounded from morning to night by a crowd of spectators. I cannot think it probable that the Government of France, anxious to promote improvements, and to strengthen the hands of French agriculture, will decline the benefit which is offered to them by the possession of these approved machines.

Under the law as it at present stands the cost of introducing a tile machine into France exceeds the prime cost of the machine. Mr. Clayton thus reports his experience:—

"The sale of tile machines for France would have been much greater, but the numerous applicants were deterred by the high rate of duty; it amounts, indeed, almost to a prohibition. I sold, the other day, a tile machine and pug-mill, to be delivered at Fresnes, near Paris. The sale value of this machinery amounted to 58*l.*; the cost for transport and Douane charges amounted to 62*l.*—4*l.* more than the entire cost of the machinery."

The threshing-machines were tried by the jury of Class VI. The English machine by Hornsby, and the American by Pitts, of Buffalo, State of New York, were the most approved. The

details of the trials have not yet been published, and they are not in my possession.

These trials do not appear to have been conducted with all the care and exactness necessary to place the decisions beyond the reach of cavil.

Reaping Machines.

Though reaping machines have, up to this time, disappointed the sanguine expectations which were formed of them at their first appearance, the various specimens in the Exhibition were regarded with much curiosity, and the trials of them excited a lively interest. Mr. W. Fairbairn, President of Class VI., has favoured me with the following report on these machines. The name of Mr. Fairbairn will be a sufficient warrant for the value of this report.

Report on Reaping Machines.

Machines of this kind are of great antiquity. They were known to the Romans, but we hear nothing of them during the middle ages; and from those remote times we have few traces of improvement, or any successful attempts to substitute machine-reaping for the sickle. It was reserved for Mr. Bell of the Carse of Gowrie, in Scotland, in 1826, to construct a machine that answered all the purposes of a good reaper. Mr. Bell has used his machine, and gathered his harvest by it, for the last twenty-nine years, and it is not too much to say that most of the machines now in use are based upon the principle of Bell. There is great similarity in nearly the whole of these machines, and the Universal Exhibition of Paris exhibits nearly the same characteristics in principle and construction as those shown at the Exhibition of 1851. It is true there are some slight improvements introduced by Mr. M'Cormick and others, but the principle of the machine remains unaltered, excepting only the receiving-boards, which in those brought forward for competition at the Paris Exhibition are exceedingly variable, and some of them very ingenious.

The period of the General Exhibition at Paris was most favourable for giving a fair trial to machines of this description, and the month of August afforded an excellent opportunity for testing the merits of each machine by actual experiment. Through the liberality of M. Dailly, a distinguished agriculturist, and member of the jury, a field of oats on his farm at Trappe was set apart for the exclusive purpose of ascertaining the properties and proving the value of each machine. The Imperial Government, always alive to the interests of the community and the advancement of mechanical art, took a deep interest in the trials, and, in

order that the jury might not be incommoded, several mounted gens-d'armes, a few soldiers of the line, and a drummer, were sent forward to Trappes to prevent the crowd from inconveniencing them. On the 2nd August, at 11 o'clock, the machines were divided into three groups, and the contest for superiority commenced as follows :—

		Metres.
Group 1st,—		
M. Cournier's allotment	.. ..	1,628
M. Atkins' „	.. ..	1,733
M. Lawrent's „	.. ..	1,825
Group 2nd,—		
M. Mazier's „	.. ..	1,826
M. Manny's „	.. ..	1,900
M. Crosskill's „	.. ..	1,958
Group 3rd,—		
M. M'Cormick's „	.. ..	1,987
M. Dray's „	.. ..	2,256
Canadian „	.. ..	1,650

Having grouped the machines as above, the conditions were, as far as I could learn,—the time required to cut the allotment, the number of hands employed, and the perfection with which the work was executed without injury to the grain. These conditions being ascertained, the first group commenced operations, by beat of drum, at 11 o'clock, all three starting at the same time.

Group 1.

Cournier's Machine (French) on Bell's principle.—This machine, with one horse, cuts clean, but is liable to get entangled in the cutters with straw. A great deal of time was lost from this cause, and this defect appears to be common to all the machines when the speed happens to be reduced under 2½ miles an hour. In this respect I found the maximum velocity of the machines to be as nearly as possible 3 miles an hour; and the knives, for every 18 feet in distance, made 11 single or 22 double cuts for one revolution of the wheel. This machine had a sliding rake motion for the convenience of the reaper, and in order to enable him to clear the receiving-board of the grain as it is cut. With some improvements, this machine may be made much more effective, and would work much better with two horses and a wider cutting-board, so as to take a greater width of grain, and maintain the speed necessary to accomplish a maximum result. From the frequent clogging of the cutters it required 67 minutes to cut 1628 square metres of corn. The reel in this machine for gathering the corn went too fast, and proved injurious by striking the grain too high up the stalk.

M. Atkins' Automaton Machine (American) executed 1733

square metres in 24 minutes. This machine is nearly self-acting, and only requires the driver; one attendant, indeed, following the machine in case anything goes wrong. Its novelty consists in a rake worked from the wheel that drives the cutter-shaft. It is attached by an arm or connecting-rod to the bevel-wheel, and by a combination of levers it receives a rotatory motion, which, along with that in a longitudinal direction, drags the grain forward over the side of the board. In order, however, to make sure of the discharge, another rake or cleaner strips the before-mentioned one of its load, and lays the straw in parallel lines ready to be bound into sheaves. This machine, like Cournier's, has some clever devices about it; but, like all new attempts at improvements, there still remain some further improvements to simplify and make the machine more effective and complete.

Lawrent (French).—This machine, like Cournier's, was constantly choking with the straw round the cutters. It is a copy of Bell's, and requires two men at the pole—a driver and a reaper—to work it. It is a heavy machine, and almost too much for two horses to work, and the reason of its entanglement was a falling off in the speed. In all these machines speed is an element of success, as might be seen whenever the velocity of the knives and the speed of the machine were reduced; on such occasions, choking or entanglement of the straw was the result. This being the case, it is therefore a consideration of much importance to have all these machines of such dimensions as to enable the horses to work them with ease at the required velocity.

GROUP 2.

Mazier's Machine (French).—This machine is of light construction, adapted for one horse, and cuts a breadth of 2 feet 7 inches in line all round the field. It cuts either right or left, by means of the frame containing the cutters turning on a central axis. The knives are worked by a wheel and worm, and are well calculated for cutting light grain, such as oats and barley, but might prove inefficient in operation on a field of heavy wheat. The machine, as a whole, was rather slender for the work it had to perform; but, if well constructed, and the parts judiciously proportioned for two horses, there is no reason why it should not reap any description of grain. In the attempt to cut the allotment it unfortunately broke down by some of the parts giving way.

J. M. Manny (United States).—Mr. Manny's allotment consisted of 1900 square metres, which he cut in 26 minutes. The machine is worked by two horses, and cuts a breadth of 4 feet 6 inches. Mr. M. speaks highly of his machine, and

gives numerous testimonials of its efficiency, exclusively of medals, premiums, and awards from different districts in America, and from different countries in Europe, for its performance. According to Mr. Manny's account, "it will cut either grass or corn when down, wet or dry, and in whatever direction the wind blows, without being stopped for a single instant." Mr. M. further observes, "that it can easily be converted, in a few seconds, from a reaper into a mower, and the only thing required is to withdraw the platform and change the scythe of the reaper for the cutting scythe of the mower. The cutting apparatus, for corn or for grass, is made in such a way that it cuts as well backwards as forwards when the machine is reaping; the wheat is received on the platform, gathered, and put into a heap by the action of a wing-board, and by a single stroke of his rake the attendant puts down on the ground at the back of the machine the already made sheaves, which only require tying." It will not be necessary to follow Mr. Manny further in his description, which evinces great confidence in the superior performance of the machine; suffice it to observe that it did its work, with the exception of some parts not very clean cut, moderately well, and in 26 minutes completed the quantity it had to perform.

Crosskill's Machine (English) is an improvement upon Bell's, and in great repute amongst the farmers of the North Riding of Yorkshire and other parts of England. In the hands of Crosskill it has received several improvements, but unfortunately on this occasion the key of the connecting-rod that works the knives got loose, dropped out, and stopped the process of reaping. Under these circumstances it was thought desirable to withdraw the machine, and leave the field open to the other competitors.

Group 3.

M'Cormick (American).—This reaper is probably one of the best machines of its class. It reaped 1987 square metres in seventeen minutes, and judging not only from the quantity of work done in so short a time, but from the manner in which the ground was cleared, and the grain cut, it evidenced much greater perfection in its operations than any of the others whose powers were brought to the test. It cuts a clean track of 5 feet 6 inches wide, and performs the operations with a degree of certainty and precision sufficient to account for the very short time in which the allotment was cut down. This machine, like most others, is susceptible of still further improvements, and I am glad to find that Messrs. Burgess and Key, the makers, are about to introduce a new moveable apparatus, consisting of three Archimedean screws, for delivering the grain from off the receiving board as it is cut. The great defect of this machine was the

imperfect way in which the grain was delivered from the platform after being cut, and the evident want of some method of laying the heads and straw parallel and in bundles and sheaves, and also for clearing the ground and leaving the track clear for the horses on the return cut. This defect in distributing the cut grain as it falls from the knives appears to be the principal objection to this machine. Burgess and Key's clearing apparatus, if properly constructed, may probably remedy this evil, and render the machine much more perfect in its operations than it has been heretofore.*

W. M. Dray and Co.'s Machine (English) is of an exceeding compact form. It is entirely without a reel for gathering in the corn to the cutters, and requires only one man as a reaper to watch the cutters and discharge the corn as it is received upon the board or wooden platform behind. The cutters are 5 feet wide, and it reaped 2250 square metres in 35 minutes.† The peculiar features of this machine are, its portable construction and the receiving-board, which moves upon an axis. By the pressure of the reaper's foot the platform is tilted, and the grain drops behind, ready for the person who follows to bind and tie it up. The only objection to this process is that it requires the binding to be done immediately, otherwise the horses, at every succeeding cut, would trample over the previously reaped corn, and, moreover, would effectually impede the working of the machine. Under these circumstances the track previously cut must be entirely cleared in order to prepare for that which succeeds. This operation of the tilting-board, which throws the grain upon the track behind, appears to be the chief defect in the machine. A different clearing apparatus to effect the discharge of the cut grain in a lateral direction would render this machine much more valuable. It would give time for binding up the grain into sheaves, and at the same time it would clear the track for the horses and machine in their return for the next cut.

The last machine (the Canadian), which completes the three groups, was withdrawn, from some cause that was not explained.

On a careful examination of the several machines entered for the prizes, it will be observed that in every one of them an attempt was made to effect a certain purpose by certain means of transmission, calculated to retard rather than facilitate the progress of cutting. In machines of this description, where horses

* A trial has been made of this apparatus since the above was written, but without success. I am not prepared to state from what cause, but will take an early opportunity of ascertaining the facts or of witnessing its performance at some future trial.

† Some say 34 minutes.

are employed as a motive power, it is desirable to make the action as easy as possible, and to effect the motion of cutting, reaping, &c., with as light wheels and gear as practicable. Now, these small wheels and their attachments at present in use appear to me to be the very worst and heaviest parts of the machine, and I would earnestly urge upon the makers of reaping-machines the absolute necessity of increasing the diameters and dimensions of the gear which works the cutters, and at the same time to fix and attach the journals and ends of the shafts into one casting, so that they cannot vary in position, but must move, and, technically speaking, go and come with the machine. These alterations being made, the proper clearing apparatus being attached to the receiving-boards, we might then look forward to the labours of the harvest being performed with much greater certainty and effect than is now accomplished by the present machines. The following table, which Mr. Edward Combes has kindly handed to me, gives the results of the different trials as follows:—

TRIAL of REAPING MACHINES on the Farm of M. DAILLY, at Trappes, near Paris, 2nd August, 1855.

No.	Name.	Country.	Breadth of cutting.		Square metres.	Time.	No. of horses.	Price.	Remarks.
			ft.	in.		min.		£.	
1	Cournier. .	France .	4	3	1,628	67	1	26	Driving-wheel 3ft. 3in.; crank makes 11 revolutions to 1; knives not serrated.
2	Atkins . .	American.	5	3	1,733	24	2	36	Diameter of driving-wheel 4ft. 4in.; crank makes 24 to 1.
3	Lawrent. .	France .	5	0	1,825	66	2	..	Diameter of driving-wheel 3ft.; crank makes 15 to 1; similar to Bell.
4	Mazier . .	France .	2	7	Broke down		1	..	Small machine, cutting either right or left, by means of the cutting-frame turning on a central movable axis; knives worked by wheel and worm.
5	Manny . .	American.	4	6	1,900	26	2	26	Diameter of driving-wheel 2ft. 6in.; crank makes 13 to 1.
6	Crosskill, Bell's .	England .	5	0	Broke down		2	45	..
7	M'Cormick .	American.	5	6	1,987	17	2	30	..
8	Dray . . .	England .	5	0	2,250	35	2	25	..
9	The Canadian	..	6	6	Retired		2	..	..

From the above table it will be seen that M'Cormick's American machines performed the most work in the least time; that Atkins' and Manny's executed as nearly as possible the same quantity of work in the same time, there being a fraction in

favour of Manny; and that Dray was next in the order of time and the quantity of work done.

Reducing the whole work done to a standard of 2000 square metres, the competing machines will stand thus:—

M'Cormick's	would cut 2,000	metres in	17·00	minutes.
Manny's	,,	,,	27·36	,,
Atkins'	,,	,,	27·69	,,
Dray's	,,	,,	31·11	,,

If we are, therefore, to take the quantity of grain cut in the least time, Mr. M'Cormick's machine will stand first on the list, and the others according to their position in the above scale.

In the investigation of this subject we have hitherto confined our observations to the machines. There is, however, another element equally important and essential to the efficiency of the process of reaping, and that is, *the preparation of the land*: and in fact, before we can look forward to ultimate success, the surface must be levelled, and the present injurious system of ridges dispensed with. To a casual observer it is obvious that the present state of culture, as pursued in most parts of Europe, is not calculated to afford the necessary facilities for insuring a successful progression to machinery. To apply machinery successfully to the labours of a farm the land must be prepared, not for hand, but machine labour; and the successful introduction of reaping machines will chiefly depend upon the preparations that are made for their reception. The system of ridges may be tolerated, and overcome by the sickle, but to give to the new process of reaping by machinery its full effect, a totally different plan of operations must be pursued, and the fields laid down with a perfectly smooth surface. The larger description of stones and other obstructions should be removed, and in place of the superfluous water not required for the nourishment of the plants being allowed to flow between the ridges on the surfaces of the field, sweeping in heavy streams, as it now does, everything before it, the new system of drainage will require to be adopted, and the water carried under in place of running over the surface.

To make a machine, such as a reaping-machine, work well, everything must not be left to the machine; the agriculturist must do his duty as well as the engineer, and that duty once duly performed on both sides, a certainty of action will be secured which will solve the problem and effect satisfactory results. Having arrived at these happy results, we may then, *and not till then*, reasonably look forward to the crops being well and quickly gathered by machinery, to the exclusion of a laborious process, effected with difficulty, and often imperfectly, by the human hand.

W. FAIRBAIRN.

I regret that the Exhibition closed without any declared progress in the great problem of steam cultivation. Hopes had been entertained that a steam cultivator, the invention of Mr. Romaine, brought from Canada, promoted by funds voted by the Canadian legislature, would have been so far perfected, that it might have been presented to the jury for examination; but unforeseen difficulties beset the path of the inventor, and he was compelled reluctantly to give up the cherished hope of signalising his machine by a public display at Paris.

Still it is just to Mr. Romaine that I should bear testimony to what I saw, and to the point which he had attained. I saw in a field, near the walls of Paris, Mr. Romaine's machine, carrying its own boiler and engine, travel by its own locomotive power 100 yards up the field, and break up and cultivate the land in its course.

Besides taking the lead in promoting cultivation by steam, the Canadian legislature voted a large sum of money (10,000*l.* currency) for the general objects of the Exhibition, and sent some good machines and a magnificent collection of products.

The Exhibition of 1851 brought favourably into notice the great resources of Canada, increased the general confidence in the security of sums invested in its public works, and facilitated the introduction of capital into the colony. The display which was made at Paris cannot fail to fix on broader and firmer foundations the confidence in the natural resources of the colony, and in the intelligence and public spirit of its inhabitants.

The sales of English agricultural machinery have been for some years past much more extensive to the German states than to France.

Belgium exhibited some good machinery; the first prize was awarded to her for churns and for chaff-cutters. The Commissioners of her Government were diligent in turning the Exhibition to good account. They purchased several of the best English implements, which will no doubt speedily be reproduced, possibly with improvements, in her active and well-appointed workshops.

It may be sufficient for the purposes of this report to say of the foreign agricultural machinery in general, the collection of which was very large, and of which only a small portion was subjected to trial, that, without venturing to express an opinion of the merits of some of these implements, or of their adaptation to the different localities where they were employed, it did not appear to our machine-maker or to our consulting engineer that they offered models which it would be important to adopt for the purposes of English farming.

Gold medals of honour in Class III. for agricultural machinery

were awarded to six individuals only. Five of these exhibitors were from England, and one from the United States of America.

Grand Medal of Honour.—Mr. M'Cormick, of Chicago, United States of America, for his reaping-machine.

Medals of Honour.—Messrs. Garrett, Saxmundham; Hornsby, Grantham; Howard, Bedford; Ransome, Ipswich; Crosskill, Beverley; for agricultural machinery.

Agricultural Products.

The collection of agricultural products was very large, and of high interest. To give a detailed account of them would extend this report beyond reasonable limits; nor for the purposes of this report does it seem necessary, as in the majority of instances there was no question of comparison or competition.

The fine wools of Germany were a class to themselves.

The tobacco of Cuba was without a rival; various specimens, the produce of the soil of Europe, followed at a respectful distance.

In the important article of flax, France, Belgium, and Ireland received an equal award from the jury.

The rich and varied products of the wide domain of France and of Algeria were set forth in long and imposing array.

The agricultural products of these islands were combined in a single collection, formed by my colleague, Mr. Wilson, under the directions of the Board of Trade. It was very complete, carefully arranged and classified, and called forth the warmest commendations of the jury.

No unimportant share of the interest of the Exhibition was supplied by the dependencies of the British Crown, by India, by the continent of Australia, by Van Diemen's Land, by Jamaica, Guiana, &c. The value of their contributions was fully appreciated, and suitable acknowledgments were made by the votes of the respective juries.

Amid all the beautiful specimens of wheat from Algeria, from Australia, from Van Diemen's Land, from Canada, it was admitted that no single specimen equalled in excellence the specimen sent from South Australia to the Exhibition of 1851. It does not appear, from the information that has reached me, that these fine grains sown in this country retain the excellence of their original type. Grains matured under a hot sun form, according to the commonly received opinion, the most valuable seed; but in the case of wheat the practice seems to be the reverse of this. It is certain that our strong and prolific wheats are imported largely into France for seed. Not less than 5000 quarters were imported early in last autumn for this purpose. These strong and coarse wheats no doubt refine in colour and in

quality under a more southern sun. It does not appear that the exchange of the fine grains of the south to our northern latitudes is attended with results equally advantageous.

It would be desirable that some careful experiments should be made to induce to greater certainty on this point of so much interest.

Among the specimens of artificial manure, that made from fish, the *Engrais Poisson*, was considered by Professor Wilson specially worthy of notice.

The fish, after having been steamed, are pressed into cakes and dried. In this form the manure is said to contain from 10 to 12 per cent. of nitrogen, and from 16 to 22 per cent. of phosphate. The price, about 8*l.* per ton.

Progress since 1851.

In reply to the second, and not least interesting question—"What progress has been made since 1851?" it may be confidently asserted that progress has been made on every side. In machinery, in scientific acquirements, in field practice; and to such an extent, that beyond all question the productive powers of these kingdoms have been more largely increased within the last four years than within an equal space of time at any former period.

In machine making, though some interesting novelties have appeared, the characteristic feature has been the constant improvement, tending to perfection, of our established implements, and a great extension of their use through the body of the farming community, a fact significant of the superior intelligence which is now brought to bear on farming affairs, promising a sure and continued progression.

First on the list in point of interest, first in its remarkable increase, stands steam machinery.

No farmer who has ever had a steam-engine on his farm will ever again be without one; no farmer who has ever threshed his corn with steam power could bear again to see his horses toiling in the wearisome circle, now jerking onwards when the whip sounds, now brought almost to a stand-still when the machine is clogged by a careless feeder. The regular stroke of the untiring steam-engine gives excellence to the work, keeps everybody in his place, and introduces among men, even the most careless, something of its own exactness and precision.

It was thought a remarkable thing that in the year 1851, one firm, Clayton and Shuttleworth of Lincoln, a firm not known to the agricultural world ten years ago, should have constructed and sold in one year 140 portable steam-engines. Since 1851 the annual progress has been as follows:—

	Engines.	Aggregate horse power.
1852	sold 243	1,349
1853	„ 293	1,723
1854	„ 363	2,297
1855	„ 491	3,332
	1,390	8,701

Besides the constant increase in numbers, it will be seen there is a constant increase also in the power of the machines. In the year 1851 each engine averaged scarcely the power of five horses. In the year 1855 they average nearly seven.

It is computed that 90 per cent. of these engines are used for agricultural purposes in England; the remaining 10 per cent. are sent abroad, or are used for purposes not connected with agriculture. We have therefore in the last four years, deducting 10 per cent. from the whole number of 8701, a power equal to 7831 horses added to the force of the farmer from one firm alone. Messrs. Clayton and Shuttleworth direct their attention exclusively to steam-engines, and to machinery moved by steam power, This devotion of the undivided attention to one class of objects is of itself an indication of progress, and conducive to perfection.

The increased power afforded by steam has led to improvements in all machinery moved by steam—in none more than in threshing-machines. The corn now is commonly delivered from the stack upon the machine, and delivered from the machine into sacks ready for market—a great economy of time and of money. For these and similar processes, the use of steam power is making rapid strides, and will continually extend itself, to the great help and furtherance of every operation to which it can be applied.

Our leading machine-makers all concur in attributing marked results to the Exhibition of 1851.

Messrs. Garrett have foreign orders, arising from connexions formed at the Exhibition, still coming in. One customer in Hungary has had not less than 8000*l.* worth of machinery, chiefly drills and threshing-machines. Drills have been improved by a new steerage patented in 1854.

Chambers' patent manure distributor is a new instrument, the invention of a practical Norfolk farmer; it will sow from 1 to 100 bushels of artificial manure per acre, delivering it with great regularity, and is excellent for the simplicity of its construction.

Drills for liquid manure are still undergoing improvement. If found useful in this country, how much more valuable are they likely to prove in the dry and sun-burnt plains of southern Europe?

Messrs. Hornsby consider the improvements in threshing-

machines to be equal to a new creation of the implement. Their business has increased three-fold since 1851.

Messrs. Howard find the demand for improved implements to come now mainly from the tenant farmers; formerly it was in a great degree confined to amateurs and large proprietors. The business of all the leading machine-makers has doubled since 1851.

Messrs. Ransome concur as to the improvement in threshing-machines, and as to increased demand for machinery. Much has been done, but much remains to be done still.

Messrs. Smith and Ashby date the wide diffusion of good implements from the Exhibition of 1851. The Paris Exhibition has opened to them several new sources of trade, in France, Algeria, and Germany, and has led to the appointment of an agency in Berlin for the introduction of improved machines into Germany, at the instance of a spirited merchant of that city.

Messrs. Bentall have found the demand for improved machinery increase largely since 1851.

Such has been the uniform tenor of the replies from all the leading machine-makers from whom communications have been received. There is a host of local makers, equally alive to the importance of improvement, and adding largely in their respective spheres to the stock of good implements.

Agricultural Chemistry.

In speaking of the progress of agricultural chemistry, to Mr. Lawes must be assigned by English farmers the place of honour. Without entering on the high controversy between Baron Liebig and Mr. Lawes, lately revived with increased animation, the English farmers have wisely accepted the teaching of Mr. Lawes, based on experiments, in the accuracy of which full reliance may be placed, and the results of which are open to the view of all. They have learnt that the approved artificial manures are not mere stimulants, but agents of fertility which, when properly applied, may be depended upon with certainty to produce a crop. The principles on which the growth of corn depends are better understood. The repetition of corn crops on the same soil can no longer be considered as necessarily faulty in principle, and to be unconditionally condemned. It is rather a question of expediency, to be decided by the costs of manure and of produce.

These lessons the English farmers have learnt from Mr. Lawes. They have accepted them with becoming gratitude. They are practising them with increasing confidence day by day, to their great and proved advantage.

Mr. Way, to whom also the farming world is under the greatest

obligations, has snatched a few moments from his professional pursuits to furnish me with the following sketch of the general progress of agricultural chemistry.

This department of applied science is now attracting to itself the attention of able chemists in all countries; and the contributions to knowledge resulting from the various investigations have during the last few years been very considerable. To attempt anything like an account of these results in this place is obviously out of the question, and we content ourselves with little more than an enumeration of the principal and most interesting investigations.

In this country Mr. Lawes has continued his experiments on the laws concerned in the feeding and fattening of animals, taking, for the objects of trial, pigs and sheep. The number of animals experimented upon, the intelligence and care brought to bear upon every detail of the experiments, and the very considerable expenditure which has evidently accompanied them, place these investigations far in advance of any of a similar kind that have been undertaken elsewhere. Although the results are of a practical character, the experiments of Mr. Lawes must not be classed with the very numerous trials on the feeding of animals that are to be found dispersed through agricultural publications, and which are *merely* practical, being undertaken without reference to general principles. The results of Mr. Lawes' inquiries are too numerous to be stated here, but they seem to point out that a just balance of the different constituents of food is of more importance in the feeding and fattening of cattle than a predominance of any one; that neither the albuminous nor the farinaceous elements of food have an exclusive value for the purposes to which they are applied; and that the classes of vegetables which are peculiar in containing a high proportion of nitrogenous matter are not necessarily, from that circumstance, the most adapted in practice to produce that part of the animal body (muscle) which most resembles them in composition. According to Mr. Lawes, therefore, the valuation of foods in relation to their contents in nitrogen is attended with much fallacy.

Amongst other papers, Dr. Voelcker, of Cirencester College, has published an account of experiments made with a view of ascertaining the cause of the fertility produced by burnt clay when used as manure. He has arrived at the opinion that the effects are partly mechanical, but principally due to the liberation of potash from silicates of that alkali existing in the soil, but only slowly available until released by torrefaction.

Mr. Way has published two further papers on the important subject of the absorption of manure by soils, in continuation of his first research on this subject, which was published in 1850.

Mr. Way attributes the power possessed by soils to remove various alkaline bodies (as potash, ammonia, &c.), from solution in water, to the existence of a class of double silicates of alumina and another base, which is generally lime or soda. Mr. Way has succeeded, for the first time, in producing this class of salts; and he argues, from the effects observed in soils, that these latter contain the silicates in question in small quantity, and hence their power to preserve soluble manures from loss by rain and drainage. His second paper on this subject refers to the action of lime on soils; and he endeavours to show, from the large quantity of ammonia existing in almost all soils, which, according to his experiments, very far exceeds the doses of this alkali usually applied in manure, that lime acts much in the same way as ammoniacal manures themselves, by furnishing indirectly a supply of nitrogen to plants. The effects of over-liming are accounted for in the same way.

Mr. Way has also given an account of his examination of certain beds lying immediately below the chalk formation, which contain large quantities of what is known to chemists as "*soluble silica.*" This form of silica has not hitherto been met with naturally, except in the case of some strata in the Department des Ardennes, in France, which were examined four or five years ago by M. Sauvage. From their peculiar nature they are supposed to be available with advantage for many purposes in the arts, and as a source of soluble silica for agricultural use.

The subject in the chemistry of agriculture, which has lately, however, attracted the greatest share of attention, both in this country and abroad, is that of the source from which plants derive their *nitrogen*. It has been satisfactorily proved that plants growing in the ordinary way often contain more of the element nitrogen than they can obtain from the soil in which their roots are placed; and it is obvious that in some way or other this accumulation is derived from the atmosphere. Now, the air surrounding the globe is composed of a mixture of nitrogen and oxygen gases in the proportion of about four parts of the former to one part of the latter; it also contains small quantities of other gases, such as carbonic acid, nitric acid, and ammonia. The question at issue is, as to whether plants can, under any circumstances, make use of the great bulk of the nitrogen of the air in building up their tissues, or whether they derive the observed excess from the ammonia and nitric acid in the air. This question, the interest of which, both in a purely scientific and agricultural point of view, can hardly be overrated, has enlisted the energies of chemists on both sides, and has given rise to some admirable researches. It has also involved the extended examination of air and rain-water, in order to ascertain how

much ammonia and nitric acid are usually contained in the one, and brought down by the other. The principals in this discussion in France are MM. Boussingault and Ville; both of these chemists have made extended series of experiments on plants grown in glass-cases; their conclusions are, however, diametrically opposite,—M. Boussingault contending that plants cannot make use of the atmospheric nitrogen, but must be indebted to the nitric acid and ammonia in the air for their supply in excess over that furnished by the soil; M. Ville maintaining that, in the absence of both of these, an increase of nitrogen in plants still takes place. A Commission of the French Academy of Sciences, recently appointed to look into this matter, leans rather in its report to the side of M. Ville, but the question is still far from being set at rest.

M. Barral has determined the quantity of ammonia and nitric acid brought down by rain in Paris. M. Boussingault has repeated these experiments as regards ammonia in Alsace, and finds the quantity very much smaller than in the rain of the city, a circumstance which we should be prepared to expect. M. Boussingault has also examined, with the same object, the water of fogs and dew, and of rivers and streams. M. Ville has carefully determined the ammonia existing in the air both in the interior and suburbs of Paris.

Mr. Lawes and Dr. Gilbert have published the results of an inquiry into the quantity of ammonia and nitric acid in rain falling at Rothamsted, in Hertfordshire. The methods of determining small quantities of nitric acid are at present so imperfect, that Messrs. Lawes and Gilbert have not thought it well to publish their results as to this substance, but they are led to believe that in quantity it exceeds that of ammonia in rain. Besides the names we have mentioned in connection with these researches, other continental and English chemists might be referred to, if circumstances admitted of greater amplification. It is, however, obvious, that in this hurried sketch we have omitted all notice of many investigations on this and other subjects of agricultural chemistry which might well claim attention in a more extended review.

Finally, we must not omit to mention, that the trade in artificial manures, which is rapidly rising into such national importance, especially in England, is receiving the most important aid at the hands of chemical science. Not only are the various waste substances of manufactures and of daily life worked up into available form, but the manures produced by chemical means, more especially the superphosphate of lime, are daily improving in character, mainly through the suggestions of chemists who have specially devoted themselves to this branch of

science. Fresh sources of guano have also been discovered, and new supplies of substances useful to the farmer have in several places been obtained.

It is, therefore, not without reason, that we congratulate ourselves on the progress which has, within the last five years, been made by that department of agriculture which is based upon chemical science.

FIELD PRACTICE.

The greatest improvements in cultivation and management have taken place in the strong lands. Draining is the foundation of all these improvements. Draining, now better understood and generally well executed at a sufficient depth, has changed the character of whole districts, turning unmanageable and unprofitable soils into easy-working and productive land.

It would be interesting to ascertain the extent of land drained each year, but no sufficient data exist for a reliable estimate. Draining operations are carried on by means of the public loan, the capital of private companies, and of individual proprietors.

Of the public loan of 4,000,000*l.*, the sums issued for works in each of the last three years have been—

1852	£410,478
1853	318,637
1854	322,728
	£1,051,843

What proportion do the lands drained by the public loan bear to the lands drained by private capital? If this district may be taken as a fair sample of the whole area of the country, the lands drained by the public loan would not be more than one-fourth of those drained by private capital. In such case, the total sum expended in draining for the last three years would amount to 5,257,615*l.*, and allowing 5*l.* for the expense of an acre, the extent of land drained would exceed 1,000,000 acres. This sum, or whatever sum may have been expended in draining, will have been capital supplied mainly by the proprietors of land. A sum equal to the above in amount has been expended mainly by the tenant farmers of the three kingdoms, in the purchase of a single article of manure; and this is not a vague estimate, but an ascertained certainty.

The sales of Peruvian guano by Messrs. Gibbs for the last three years have been—

	Tons.
1852	118,000
1853	135,000
1854	177,000
	430,000

Allowing 12*l.* per ton for cost and carriage, the sum expended amounts to 5,160,000*l.*

To this must be added the large outlay on linseed cake, on bones, rags, on minerals containing fertilising principles, on lime, plaster, &c. With these combined efforts on the part of the owners and occupiers of the soil, there can be no danger in asserting that the productive powers of these islands have largely increased, and are continually gaining new force.

I have said that the most marked improvement has taken place on the strong lands. Draining and autumn cultivation, materially assisted by good implements, have enabled the occupier of strong land to add Swede turnips to his course of cropping. The importance of this addition is beginning only to make itself felt. This root, which, with its different varieties, created the value of the light lands, is now performing a service almost as great to the strong lands, not, as on light lands, for feeding sheep, but for feeding cattle. The quality of the turnips grown on strong lands is greatly superior. The land will bear the whole crop to be carted off to feed cattle in yards. Cattle supply manure, manure gives corn. It is difficult to estimate the addition, in meat and in grain, which this alternating process will surely afford.

It may be thought by some that too much stress has been laid on the value of improved implements. It may be worth while to examine the point more closely.

What saving might be effected on a farm of 200 acres of arable land, (the rental, say, 25*s.* per acre,) drained and laid into fields of a suitable size, by the use of good implements? All land is ploughed at least twice a year. The difference in labour between ploughing drained or undrained land is very great.

It would be an estimate much below the mark to put it at 1*s.* per acre for each ploughing.

For the year 2*s.* per acre.

The next process would be sowing the seed.

On the old system, 2½ bushels of seed wheat would be sown broadcast per acre.

On the new system, with an improved drill, 1½ bushel would be sown with better results.

There would be a saving, therefore, of one bushel per acre on the 50 acres sown with wheat, which, at 7*s.* per bushel, amounts to 17*l.* 10*s.*, or per acre, over the whole area, 1*s.* 9*d.*

On 50 acres of barley there would likewise be a saving of one bushel of seed per acre, which, at 4*s.* per bushel, would give a saving per acre of 1*s.*

Next comes the preparation of the grain for market. There are to be threshed the produce of 50 acres of wheat, at a yield of four quarters only per acre, 200 quarters; of barley, 50 acres, at

a yield of five quarters per acre, 250 quarters. The cost of threshing wheat by the flail, and dressing, is 4*s.* per quarter; by an improved steam machine, 1*s.* 6*d.* Saving on 200 quarters of wheat, 25*l.*, or, per acre, 2*s.* 6*d.* The cost of threshing barley by the flail is 3*s.* per quarter; by steam machine, 2*s.* Saving on 250 quarters, 12*l.* 10*s.*, or, per acre, 1*s.* 3*d.*

Total saving by the use of drill and threshing machine, 8*s.* 6*d.* per acre, or one-third of the rent, 25*s.*

Besides the economy and direct gain to the farmer, the saving of one bushel per acre of the grain employed in reproduction is an important aid to the consumer, and when multiplied over the total area of land still cultivated under the old system would form no insignificant addition to the annual resources of the country.

The rapid spread of useful information and of approved practice must be laid to the account, in no small degree, of the Journal and of the meetings of the Royal English Agricultural Society. The meetings of the Society, held in each year in different districts, enforce precept by example, and communicate every variety of useful information in the most attractive form.

Such are some of the proofs of the onward march of agriculture, and of the progress which it has made since the Exhibition, and, in many points, by virtue of the Exhibition of 1851. Still we feel ourselves to be only on the threshold, and much remains to be done. We ask of science to penetrate yet deeper into the secrets of Nature's laws. We ask of mechanical art to bring to our aid in the field the mighty agency of steam.

We call upon the farmers to continue and increase their efforts; so alone will they be able to keep pace with the demands made upon them by a population ever increasing in numbers and in wants, and to maintain the place in the front rank which they now honourably hold.

The verdicts of the Paris jury will be a warrant that no jealous or narrow spirit ruled its deliberations.

It is a pleasing duty, in closing this report, to be permitted publicly to acknowledge, not only the personal courtesy, but the spirit of fairness and candour, which characterized the entire conduct of my colleagues of all nations. It was my fortune, in the Council of Presidents and Vice-Presidents, and as one of the Committee of seven for the final revision of the awards, to assist in the proceedings of the Commission to their close. The same honourable spirit animated this high council, under the immediate guidance of the illustrious Prince, its President, who himself afforded an example to all of fearless impartiality and even-handed justice.

I have the honour to be, &c.

J. Evelyn Denison.

III.—*Elementary Introduction to the subject of Vegetable Physiology.* By Arthur Henfrey, F.R.S., F.L.S., Professor of Botany, King's College, London, &c.

The object of the present paper is to present a brief sketch of some of the more important bearings of physiological science upon agriculture, through the medium of certain facts, ascertained within recent years by vegetable physiologists, throwing important light upon the phenomena which occur in the growth and nutrition of plants. These are the more opportunely brought forward now, since they illustrate that most important question, recently in full debate, the influence of nitrogenous substances when applied to hasten and increase the growth of plants. We shall endeavour to explain in language comprehensible without previous acquaintance with technical terms (the "short-hand" of science), the essential points in the development of vegetable structure, without a knowledge of which we can have no secure basis for the establishment of the laws of vegetable physiology. Scientific readers may perhaps find some of the explanations too rudimentary, but it may be observed that the most important facts, those connected with the mutual relations of the cellulose and the nitrogenous structures, will be new to all those who have not made it their business to study the additions to knowledge made in the department of physiological botany during the last few years.

We shall commence by a short discussion of the relations of chemistry to physiological inquiries of the present kind, passing on to the peculiar conditions of the phenomena to be observed in plants; and then, as necessarily involved with those, we shall briefly state the methods we employ, and the nature and value of the instruments with which we pursue them. We claim the patient attention of the reader to this exordium, in order that he may be enabled to estimate adequately the importance of the minute, and, as some might imagine, trifling particulars of vegetable life, into which we shall subsequently enter.

A distinguished chemical writer * has expressed an opinion that "it is chiefly to chemistry that we must look for the extension and improvement of physiological science." With the very highest appreciation of the importance of chemistry, as one of the indispensable foundations upon which physiology must rest, or, if we may so express it, one of the quarries from whence it must derive the materials for its construction, we cannot admit that

* Gregory, 'Outlines of Chemistry,' p. 564.

this preparatory branch of knowledge should usurp the position of the guiding light in physiological inquiries. In the investigation of the laws governing the phenomena of life, the chemist must condescend to present himself as the assistant of the physiologist, just as mechanical and physical philosophers appear as the assistants of the chemist when furnishing him with his balance, his furnaces, his electrical, optical, and similar instruments of research. To attempt to deal with facts which present themselves in living bodies according to rules derived exclusively from chemical science, would be mere empiricism. It would be a treatment of symptoms, and not a rational practice directed by knowledge of the governing principles. But there is a definite order of progress in all these things, and it is inevitable and indispensable that the development and application of chemical science should precede that of physiology. The facts of vegetable and animal life are compounded of physical and chemical phenomena, modified and directed in their operations by a higher guiding power—the vital force; but under this superintendence the chemical laws display themselves in accordance with their own universal characteristics; so that while the laws of physiology cannot be discovered by chemical research alone, it is evidently more advantageous and more rational to investigate and determine the chemical parts of the inquiry freed from the consideration of the complications resulting from the interference of life.

At certain points, however, in every investigation of living things the chemist finds himself arrested, and this by phenomena to which his method of inquiry is inapplicable. He can refer to chemical laws, for example, the changes going on in the substance of living and of decaying, dead plants, but he cannot tell why the same air and water, on one hand, nourish the living stem and enable it to unfold itself continually in new growth, and on the other hand destroy and decompose the fallen trunk from which the living parts of bud and root have been removed. Before we reach this point, moreover, even without advancing our inquiries so far as the *changes* exhibited in and by living structures, simple chemical analysis of the substances forming or contained in plants, cannot be thoroughly and accurately performed without a knowledge of the anatomical condition, the material basis of physiological science. For, as needs scarcely be said, though the ultimate constituents of which minerals, as well as plants and animals, are composed, the primary elements, are the same, or of the same kind, yet, while all lifeless bodies may be studied thoroughly by tracing up their compositions to their chemical elements and their laws of com-

bination, such an analysis of vegetable or animal substances would miss their most essential characteristics.

When we meet with a mass of mineral substance, such as a block of marble, a 'nugget' of gold, or the like, we know that to ascertain the composition, it will suffice to scrape off a small portion from any part of it and analyse this to acquire a tolerably accurate knowledge of the whole. We can 'sample' it by fragments. It is far different when we have to deal with any kind of living thing. We may analyse any plant in mass, and thus ascertain its general chemical composition; but if we take separate portions of this same plant, we shall find the composition varying in every part; that of the roots will differ from that of the stem, which again will differ from the leaves, flowers, seeds, &c., and the elements will, moreover, be found to differ in each of them respectively at different seasons of growth.

This is, indeed, no more than we should expect, since plants and animals are not fixed and permanent bodies like minerals, subject only to change from the accidental influence, as it may be called, of external agents; they are objects which present continual change so long as they retain the prime characteristic, *life*. This change every one knows to be connected in almost all cases with a flow of liquid matter through the mass, conveying nutriment, removing useless matter, or otherwise importantly contributing to interrupt and restore the equilibrium or equable composition of the whole.

But this is not all; even the solid constituents present differences of composition, not only in the clearly distinct parts of the individual objects, but even within limits which can only be comprehended after a microscopic examination of the textures composing the body; and we may find widely different chemical substances collected together, lying undisturbedly side by side and maintaining their independence, in the most minute fragment of vegetable or animal substance which our instruments enable us to isolate or to perceive.

The reason of this is plain. Chemistry teaches us that all matter, dead or living, is derived from some sixty primary elements, that is, substances which, according to our present knowledge, must be regarded as simple, because we cannot decompose them. Such are the metals, for instance; but by far the most important to the physiologist are those which constitute the principal bulk of animal and vegetable substances, the three gaseous elements, *oxygen*, *hydrogen*, and *nitrogen*, and the more variable element *carbon*, which is most familiar to us in the form of charcoal. Those who have studied what

is called *organic* chemistry know that the substances constituting the structure, and contained in the liquids and solids of plants and animals, are in large proportion composed of peculiar combinations of the simple elements, formed only in bodies which possess or have had life, and which cannot be prepared artificially by the chemist from purely mineral constituents. Of these may be mentioned *cellulose*, the substance composing the main bulk of the solid parts of vegetables; *albumen*, *fibrine*, and others, which occur in modified forms both in vegetable and animal bodies; *gelatine*, an important constituent of the bones, skin, &c., of animals; together with various matters solid or liquid which occur in the interior of the substance of animals and vegetables, such as starch, oils, fat, gums, &c. A knowledge of chemistry teaches us that these matters belong exclusively to bodies which have possessed life. Thus we see that living things have what we may call compound chemical elements, known to chemists as *proximate principles*. But how these present themselves in the first instance, and what their relation is to the phenomena of life, chemistry by itself can but partially explain.

The terms organic and inorganic are now tolerably familiar to every one as used in reference to the various kinds of bodies forming the earth and its inhabitants. The word organ signifies an instrument or apparatus, and in natural science it is used in the especial sense of an instrument by which some *vital* function is performed. Thus in man and the higher animals we have organs of sense; as the eye, the instrument by which we receive most of our sensations of form, but more particularly of colour; the ear, the instrument which conveys to the mind the sensations of sound, &c. In man and the higher animals life is so complicated a phenomenon that the organs are very numerous and diverse, and they admit of classification under many different heads; the functions are for the most part distributed to different and separate organs; this being in general a mark of perfection in the scale of organization. Down to a very low point in the animal kingdom, we find systems or classes of organs, of different kinds, associated in the same body: organs of digestion, respiration, &c., of motion, and of sense, localised in particular parts of the frame, and, although acting in concert, incapable of taking on the functions of each other.

When we pass over from the animal to the vegetable kingdom, we leave behind the organs of sense and motion; those connected with nutrition and reproduction alone remain—that is to say, speaking in a general sense, and without reference to certain minute and imperfectly studied forms, which are revealed to us by

the microscope. A further peculiarity is, that while in animals it is a general rule for the organs connected with the support of the individual life, namely, those of digestion, respiration, &c., to be situated in the interior of the body—and the more completely so the more complex the apparatus—in plants the organs of absorption, respiration, &c., are turned outwards and displayed on the surface of the body; so that as regards general organization, plants have no internal anatomy; the study of their external forms corresponds to the study of the comparative anatomy of animals.

The exposure of the vital organs on the outside of the frame in vegetables is in agreement with the peculiarity of their condition as regards external objects. Animals endowed with organs of sense and motion can seek their appropriate food and convey it to an internally-situated stomach, by the surface of which, and of the rest of the intestinal canal, the nutritive matter is absorbed. Plants, fixed to the earth, devoid of organs of sense and motion, are provided with organs which in their natural growth make their way into media whence they can obtain food by simple absorption at their surface: as when roots grow into the soil, and leaves expand themselves in the atmosphere.

It has been noticed above that when we chemically examine fragments of any of the organs thus characterized, we do not find them of homogeneous or uniform constitution, made up of one, even of two proximate principles or compound elements, or of two or more of them chemically combined. We find two or more of these principles co-existent, and their relative amounts varying according to circumstances. The microscope alone can help us here. By its aid we discover that the organs which we perceive and distinguish by ordinary vision are composed of other extremely minute structures, which being, to a certain sense, complete in themselves, but associated for a common purpose, may be compared with the large organs, of which they form part, the latter being in like manner associated to constitute the entire body.

As in chemistry we arrive in our analyses at elements which cannot be further decomposed, so in microscopic anatomy we arrive at certain forms of structure which do not admit of further subdivision or separation without losing their distinctive characteristics as constituents of particular kinds of living bodies, and falling into the condition of mere organic *substances*, distinguishable only by chemical characters. For example: a potato-tuber, when in its natural state, appears nearly solid, and to the naked eye its internal substance exhibits no very complex con-

dition; yet chemical analysis would reveal the presence of starch and of cellulose, besides certain nitrogenous principles, &c. When the potato is boiled, it becomes more or less crumbling, much of it falls into the 'floury' state. A portion of this 'flour,' placed under the microscope, is found to consist of minute roundish or oval bags, of a delicate membrane, which have become more or less separated by boiling. They may be obtained in a still better condition for examination by soaking a fragment of potato for several days in water, until it appears softened and almost liquefied. These little sacs or bags are formed of the cellulose, and contain the starch and the nitrogenous principles. If we tear these sacs or crush them down, they lose their distinctive character as constituents of the particular structure of the potato-tuber, and become mere fragments of cellulose, recognizable as such by chemical tests, and thereby known to be of organic origin, but deprived of all the characteristic peculiarities as constituent parts of a particular organization.

All animal and vegetable organs are composed of microscopic constituents more or less resembling the sacs or cells just referred to in the potato. These are the final points at which we arrive in our dissection or *anatomical analysis* of organic structures. Hence we term them the *elementary organs*, for, like the large and conspicuous organs, they have a definite and characteristic form and construction, while they cannot be subdivided without passing from the condition of organs into that of mere organic substances. The larger organs very commonly contain several different kinds or forms of *elementary organs* in their composition; these, however, are not then intermixed at random, but combined according to particular laws of arrangement. Such collections of elementary organs, known by the name of *tissues*, are divisible into simple and complex tissues, according as one or more kinds of elementary organ enter into their construction. In animals, where the functions are multifold, diverse, and much localized, the modifications occurring among the elementary organs are very important and the tissues very distinct in character. In the higher animals, moreover, the large organs are so individualized that the broad general laws of physiology may be comprehended without much acquaintance with the phenomena occurring in the minute structures, on which, however, these same laws are ultimately founded.

In plants, on the contrary, the functions are not only much more simple, but they are even to a great extent diffused throughout the whole frame, and almost any part may be modified by circumstances so as to perform any function. In accordance with this, the elementary organs do not display that diversity

which exists in animal tissues, and they may, in all vegetables, be readily referred to one type, of which they are very simple modifications.

This simplicity of vegetable structures, while it renders the study of their anatomy more easy, makes this the more indispensable to the vegetable physiologist; since it is evident that if the different external organs, such as the leaves, stems, and roots, can all exercise any of the functions of vegetable life, the general anatomy or study of external form can be of little use in guiding us, and we must make ourselves acquainted with the characteristics of the elementary tissues of which any given organ is composed.

To illustrate this, we are not liable to mistake when we say that in Man and the higher animals respiration is performed by the lungs. We could not say in the same general way that the leaves constitute the respiratory organs of plants, for this function is not only ordinarily performed in part by green shoots of the stem, but in some cases, as in the Cacti, the leaves are represented by hard spines, and the stem assumes entirely the respiratory function; and yet the Cactaceæ belong to the highest class of plants. Again, the stomach and intestinal canal of animals in general are the organs for the absorption of food; and this function is only combined with others when the whole organization is very low in the scale: but in plants we not uncommonly see the roots assuming additional or different functions even in the highest forms of vegetable life; for in the turnip, carrot, and other analogous cultivated plants, the root becomes an organ not simply of absorption, but for the deposition and temporary preservation of assimilated food. In the ivy, tufts of adventitious roots spring out from the stem to form merely mechanical organs of attachment to the bodies on which the plant climbs; while the constant occurrence of adventitious or accidental roots, developed from the stem under the influence of peculiar circumstances, proves still more strikingly the modifiable character of the general organization of plants, even of those standing highest in point of anatomical structure.

Modification and change are indeed the most striking attributes of living objects, those which best mark their difference from and pre-eminence over lifeless matter: and such being the case, it must at once appear evident to every thinking mind that the study of forms or conditions existing at any one point of time can lead but a little way into the secrets of the laws of life. To trace these to their converging points, to penetrate to the inner connexion which exists in the midst of the multiformity of appearances, it is necessary to follow step by step the gradual unfolding

of the forms from the simplest to the most complicated. This leads to the recognition of the general plans upon which the whole phenomena march, and enables us to comprehend, when thoroughly studied, the difference and apparent discrepancies which are constantly observed in comparing isolated observations.

Two methods exist by which these laws of variation and combination may be studied, both of which are used by the physiologist, each assisting to clear up the difficulties of the other, and, as it were, demonstrating its problems by a different process—these are, *Comparative Physiology* and the study of *Development.* In the latter we pursue the unfolding of the individual body from the earliest and simplest recognizable stage, when it is a simple microscopic germ; in the former we are enabled to detect an analogous (but by no means similar) series of forms, with variations on different types, in the countless varieties of individual kinds which lie between the microscopic infusorium and man, or between the yeast-cell and the forest-tree.

The study of the development or unfolding of structures, constitutes the only safe foundation for a knowledge of the phenomena of life, both in the animal and vegetable kingdoms; but it stands on relatively higher ground in the latter, from the circumstance that vegetable life may be said to consist wholly of development. Almost all change here consists of the production of new structures or the completion of older, without anything which can be compared with the reparation or renewal of structures occurring in the nutrition of animals. Man and the higher animals exhibit unmistakeable examples of the effects of the nutrition of which we speak. They attain at a certain period their full growth, and, remaining for a shorter or longer period in their *prime*, then begin to descend into decay. Throughout all this period two processes run side by side,—development of new structure and absorption of part of that previously formed; throughout the first part of the life development exceeds absorption, in the latter part absorption exceeds development; but both are in more or less active operation throughout life. In plants there is no analogous set of circumstances; there exists no similar process of absorption of used-up parts. The life, excepting of course during the hybernating periods, when all the processes are at rest, as during the winter in our latitudes—the life consists of constant new formation of substance, and the form of the entire individual is undergoing constant change. In annual plants we cannot say that the individual is in its *prime* at any epoch, certainly not at the period when it is usually most attractive—that of flowering, and hardly at the time when the fruit is ripe, since then the great body of the structure is on the verge of dissolution.

In perennials the flowering and fruiting may be repeated year after year, and in trees the life is capable of extension to an indefinite period, apparently only limited by external circumstances. In a long course of existence the tree does not absorb and excrete the dead and worn out structures like an animal, replacing them in the same spot and in the same condition, but in part throws them off entirely, as in the falling leaves and the withering envelopes of the blossom, replaced on new shoots springing forth beyond them—in part overgrows and buries them, as it were, retaining them as a solid foundation for younger growth, as when the heart-wood of the oak is increased by yearly layers of new substance, or the crown of the palm is gradually elevated upon its monumental column.

The study of development is the great business of the vegetable physiologist. But the study of comparative physiology is scarcely less important when guided and checked by the other branch of research. For, as is known to every one who has mastered the rudiments of natural history, the organic kingdoms present us with countless different kinds of plants and animals, in which we recognise almost every possible different degree of complexity (or simplicity) of organization. And it is also well known that the higher forms all pass through stages which, although actually very different and with a different destiny, may be compared, as regards the physiological phenomena they present, to different perfect kinds standing fixed at successive points of elevation in the scale of organization.

The kinds belonging to the lower classes of animals and plants, from the greater simplicity of structure, admit of our examining them more completely and thoroughly in a living state. It is manifest that we could not observe the conditions of structure of a leaf or other organ of the higher plants without dissection and consequent destruction. But there exist plants of small size and simple organization, composed of merely a few *cells*, the *organic elements* of which the leaf is composed. These minute forms of life are so small and transparent, that we can see through and through them by the help of the microscope. Therefore, when anatomy proves to us that the tissues are similar, and chemistry tells us that the combinations and decompositions which take place in them are the same, we fairly conclude that our observations of the phenomena of growth and reproduction in these lower plants afford us sound data for ascertaining the laws which govern the life of the higher forms. Nature thus not only gives us, as it were, *dissections* ready-made, but she exhibits, as it were, *fragments of life* from which we may piece together the complicated sum of the life of the higher forms.

The pursuit of the development of the higher forms, from the

condition of a simple cell or single *elementary organ*, from which all take their start, through all their deviations and complications, leading to a knowledge of the conditions of all parts and at all periods, comes to our hands as the process of verification; since, so far as we at present know, it is found that the same changes and the same kinds of growth take place in a similar manner in all plants, whether they be the principal moments of life of a simple microscopic being, or subordinate and passing phenomena in the life of the mighty giants of the tropical forests whose periods of growth extend through centuries.

The elementary organs of plants are too small to be distinguished singly by the naked eye. For their investigation, therefore, it is necessary to have recourse to magnifying instruments; and hence the Microscope is one of the indispensable tools of the physiologist. The value of microscopic observations and the certainty belonging to them are no longer subjects of question among scientific men; but there still lingers perhaps among the uninitiated some of that incredulity and suspicion which almost always attaches at first to any contrivance for extending the reach of the senses beyond the ordinary range. A little reflection, however, is sufficient to show how groundless are the objections usually urged as to the uncertainty and discrepancy of the statements made by microscopic observers. In the first place the microscope is a tool requiring delicate and skilful management, and can no more be applied efficiently without practice and skill than the turner's lathe. In itself, a well-made modern microscope is a very perfect instrument, and the physiologist depends upon it as the surveyor does upon his theodolite or the navigator on his sextant. The optical principles upon which a microscope are constructed are now sufficiently understood, and the work is now so well executed, that in the majority of ordinary observations there is little danger of deception, except from the want of care in preparing the objects observed.

The utility and mode of action of the instrument may be very simply explained. With the naked eye we see objects clearly only within a certain range, not beyond a certain distance, and also not *within* a certain distance. The absolute distances vary with different persons; but any one may observe that if a piece of printed paper is held before the eye, so that the letters are clearly seen, and it is then brought gradually very close to the eye, the letters become confused, and all distinct vision is lost. The eye, in fact, consists of a set of lenses (or what are commonly called 'magnifying glasses') capable of much adjustment, but incapable of being adjusted so that objects almost close to the eye can be seen. The rays of light from such objects are not

brought to a focus on the sensitive surface at the back of the eye, and therefore vision is indistinct. When a small lens or magnifying glass is interposed in front of the eye, it condenses the rays of light (just as it condenses the rays of the sun when used as a burning-glass), and brings them to a focus on the retina, so that the object is seen clearly. At the same time, however, from the mode in which the rays of light are bent by the lens, the object is magnified; it appears larger and at a greater distance from the eye than it really is. All this may be proved with any common magnifying-glass, and is indeed no more than the ordinary action of the spectacles used by old persons for reading and other purposes, when they suffer from dimness of sight of near objects. The principles involved here are as certain as any that have been ascertained in any department of science; and the construction of the more powerful magnifying instruments used by microscopic observers is regulated by the same laws, only in a more complicated application.

In most physiological observations with the microscope, therefore, where the instrument is good, little doubt need attach to those results which depend upon things which are clearly seen by an experienced observer. But when it is considered how delicate and minute are the objects investigated, compared with those which we ordinarily see, and when it is remembered that in many cases we are reduced to *seeing* alone, and cannot touch, taste, smell, weigh, or otherwise examine, so as to control the perceptions of the eye, it is not strange that in the earlier stages of the application of the microscope much misapprehension and many errors should have arisen. To work properly with the microscope the eye requires a special education, affording it an experience which compensates for the absence of those checks which in the case of ordinary vision are supplied by the other senses. Perhaps the greatest of the practical difficulties, however, of microscopic investigation in the present day, lie in the dissection and preparation of the objects to be observed, which, from their minute dimensions and often excessive delicacy, call for the exercise of a manipulative skill demanding long practice for its acquisition, and very considerable perseverance in its application. This is especially the case in all those inquiries on which the most important physiological questions hinge. But there is no greater obstacle here than is met with in the pursuit of the other branches of natural science, and indeed in any thorough application of human intelligence. Nothing solid is to be learned or gained by man by the use of his faculties in any field without serving an apprenticeship. Chemistry worked long through doubt and obscurity, and has now proved itself one

of the most important of the aids to practical advancement in almost every branch of human industry. Physiology has vindicated its position in connexion with the art of medicine, and is daily offering new material for the still more important art of preserving health—hygiene. But in reference to agriculture its importance is not yet thoroughly recognised; nor could it be so while few of the general principles were clearly understood. These waited for the aid of chemistry. Armed with the results furnished by the sister science, and the means supplied by the great improvements made in the optical part of microscopes within the last twenty years, much may now be expected from physiology, on the laws of which indeed (the laws of life) consciously, or at present more frequently unconsciously, the whole art of cultivation, the rearing of plants and animals mainly rests.

We have said above that plants are composed of minute but distinctly characterised parts which are called *elementary* organs. All vegetable structures are made up of these, and increase in mass by their multiplication and expansion; all vegetable products are elaborated in the interior or deposited in the substance of these elementary organs. The knowledge of these elementary "atoms" then must constitute the groundwork of all knowledge of vegetable life. The examination of the essential general characters of *vegetable cells*, and their modes of multiplication, must therefore form the first step in all physiological inquiries.

If we squeeze a leaf, or any other soft part of a plant, between the fingers, we see liquid exude, showing that the substance is not solid, but of the consistence which is commonly called *spongy*. But we should mistake if we imagined that the texture is similar to that of sponge. Sponge is composed of delicate horny threads interwoven and netted together, and holds liquid in the interspaces between these threads just in the same way as a bundle of tow would do, or as the wick of a lamp soaks up the oil.

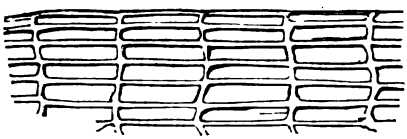
The substance of vegetables is very different from this, and the liquids they contain are not merely diffused through a porous texture, but are contained in closed cases, so that they do not escape unless the parts in which they lie are cut or bruised. If we cut an extremely thin slice of the substance of a leaf and examine this under the microscope, we find that the spongy structure is composed of a vast number of little bags filled with liquid, somewhat loosely packed together in the inside of the leaf, and we find *air* and not liquid in the interspaces between these bags.

These little bags are more easily seen in slices of the soft

parts of stems, especially of pith, such as that of the elder, where they are very large, or in the pith of rushes, the substance used for the wicks of rushlights. Slices of these structures look like pieces of network under the microscope, and might mislead a person glancing at them hastily, but the deception is readily detected; it depends upon our seeing only part of the bags (the sides) at a time, just as the joints in a piece of brickwork appear as a network of lines upon the surface of a wall.

We cannot, indeed, better illustrate the mode in which vegetable structure is made up than by comparing it with brickwork, the single bricks being represented in the plant by the little bags before-mentioned. We can imagine bricks to be of any shape, such as oblong, square, flat like tiles, &c., and then they may be packed close together; sometimes the structure of vegetables is of this form and arrangement, as especially in *bark*. If the

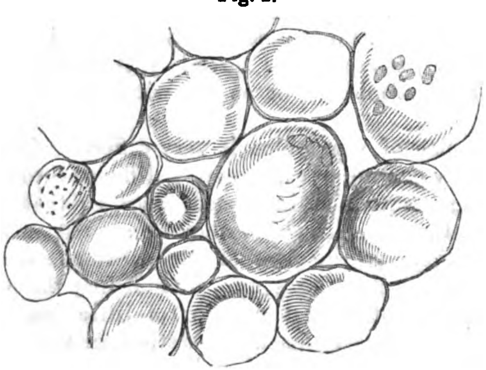
Fig. 1.



Slice of the bark of a young branch of Beech, magnified 200 diameters.

bricks were made round or oval, however, they could not be packed so as to touch at all points, but would leave passages between them, just as is the case when a number of cannon balls are piled together; the annexed drawings will represent the way in which the loose and spongy textures of plants are formed.

Fig. 2.

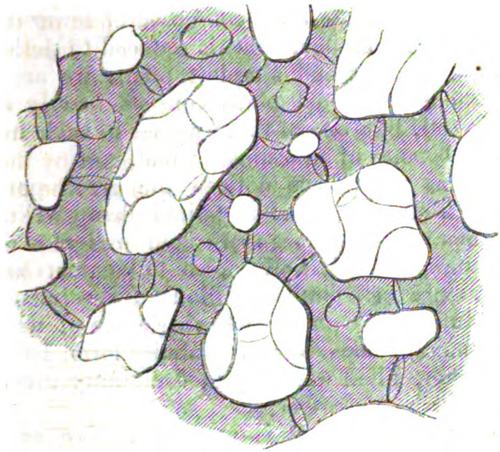


Fragment of a cross slice from the stem of the White Lily, magnified 200 diameters.

We have spoken of the minute parts of which substance is

composed as "little bags;" these have a particular name applied to them, and are called *cells*, which signifies small chambers, since, in fact, they are little chambers in the interior of the plant

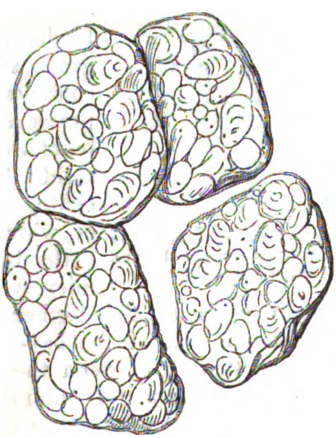
Fig. 3.



Slice of the rind of the stem of Bur-Reed (*Sparganium ramosum*,), composed of starlike cells with wide interspaces, magnified 200 diameters.

like the chambers or cells in a honeycomb. Unlike the chambers of a honeycomb, however, or chambers in a building, they are not mere hollows in a firm substance which forms partitions between them, they are really separate, closed chambers, each having its own distinct wall, so that the partition between any two is always double, and the single cells may even be separated from one another.

Fig. 4.



Cells from a macerated Potato, almost separated, and showing Starch-granules inside, magnified 200 diameters.

The substance of the potato, which seems solid to the naked eye, appears, in a slice under the microscope, as a mass of vesicles or membranous bags (filled with starch), and if a piece of potato is allowed to lie in water for a day or two, until it begins to soften and decay, on taking some of the soft portion and placing it under the microscope, we see the cells separated from each other,

each still entire, inclosing its mass of starch grains, and looking, when highly magnified, like a bagfull of oyster-shells.

The easiest way, however, to obtain a clear idea of the nature of these *cells* of plants, is to examine microscopic plants, for the size of the cell does not diminish in equal proportion to the size of the smaller plants; these are composed of fewer cells, and we can descend so far that the number is reduced to the lowest point, so that in the smallest and simplest plants we are acquainted with, the whole individual plant consists merely of a single little bag, or cell, like one of those we see in such numbers in a slice of the substance of an ordinary plant.

Most persons must have noticed the green powder which covers the bark of trees, wooden palings, damp walls, &c., looking like a mere stain. Its green colour indicates that it is of vegetable nature, and it is well known to botanists as depending upon the presence of countless millions of specimens of a very curious and interesting plant, each single one of which consists simply of a membranous bag of globular form, 1-6000th of an inch in diameter, filled with liquid containing green colouring matter.

The history of this plant is very instructive as regards the nature and mode of growth of vegetable structure, and we shall therefore describe the most important features of it.

When a small quantity of the green substance is examined by a low magnifying power it appears to consist of fine grains; but if we use a high power we find that each grain consists of a colourless bag of membrane, like a little bladder, and that it owes its colour to green substance lying in the thick liquid contents, which may be squeezed out by pressure. If acids are applied, the contents are seen to contract and become more solid; they then lie as a little mass in the centre of the bag, the colourless character of which is thus more clearly seen. These little bags or *cells* exactly represent the microscopic elements, of which all the soft green parts of the higher plants are composed. In a slice through a leaf of the bay-laurel, for instance, we see that the spongy texture between the skins of the upper and lower surfaces is composed of innumerable little colourless bags or cells of exactly the same kind, which owe their colour, in like manner, to green substance contained in the liquid with which they are filled.

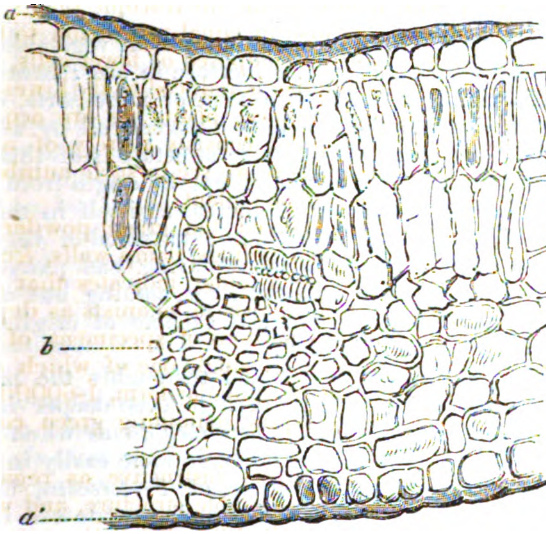
Fig. 5.

Cells of *Protococcus viridis* in different stages and forms, magnified 600 diameters.

Since the large structures of the higher plants are formed of

great quantities of these cells, and not by the mere expansion of a few original cells, it becomes a question of great interest to

Fig. 6.



Perpendicular slice of the leaf of the Bay-Laurel; *a*, *a'*, the skin of the upper and lower surfaces; *b*, a rib running through the spongy substance. Magnified 200 diameters.

know how these cells increase in number in the growth of plants. Our little *Protococcus*, or green dust, will furnish us with useful information here. Most of the cells, examined with a high magnifying power, will be found to exhibit an appearance differing a little from the simplest state above described. They will exhibit various stages of the *increase* of these cells. They will be found to display a more or less distinct line extending across and cutting them into halves, or two lines, crossing one another, and thus cutting the cells into quarters (fig. 5). These are true divisions, and by watching the progress of growth we find that the cells do become really divided in these lines, and that four cells are thus formed from each, these four at length separating and growing up by degrees to the size of the parent. This increase of size begins before they have separated from each other, so that the groups of four imperfectly divided cells are always larger than the single cells.

The increase in this case ends directly in the increase of the number of separate individuals, but it is evident that if the four cells remained adherent together, and swelled and divided again in the same manner, and went on repeating the process, the mass of cells might continue to increase in size up to any degree, and, moreover, it is clear that the larger the mass the more quickly it

would grow. Thus in the same length of time that the first cell occupied in dividing into *four*, these four may repeat the process and produce *sixteen;* then if each of these divides in the same way, the next subdivision, effected in the same space of time, will produce sixty-four, and so on.

It is exactly by this kind of operation that all vegetable structure *grows*, that all parts of plants increase in size; namely, by a division of existing cells into two, four, or more parts, each of which may swell up to the size of the parent-cell by which it is produced. And since all vegetable structure is of this cellular nature, and no plant can exist except by origin from a cell of this kind, having the power of increasing itself in this way, of course the ideas that are sometimes entertained of vegetables springing up spontaneously, without having had parents like themselves, are altogether erroneous, for nothing but a living plant can produce a reproductive cell capable of originating a new course of growth of this kind.

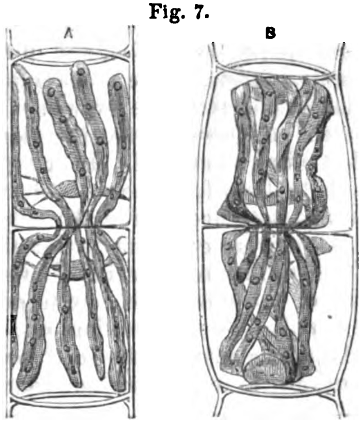
If, however, we wish to understand thoroughly the mode of increase and growth of plants, we must go even deeper into the character of the *cells* and inquire *how they divide* when giving birth to new ones. This can be observed more easily in plants composed of cells larger than those of *Protococcus*, but still small enough and transparent enough to allow us to see into the interior with the microscope. In sunny weather the surface of ditches and stagnant pools is usually more or less coated with a yellowish green froth or scum. If we take a little of this and place it in a glass of clear water we see that it is composed of numberless extremely fine green filaments, like fibres of unspun silk; if we place these filaments under the microscope we find that they are hollow, and, in fact, are formed of little tubular cases or cells joined end to end, so as to form a string of cells. The cells of such filaments present a great variety of beautiful arrangements of the cells and their contents, in the different species of these plants (called Confervoids), which are very numerous. Some are simple, thread-like rows of cells; others are branched. Some are filled with green substance; others have the green substance arranged in spiral lines or in a network on the inside of the wall of the cell. Many of them are of considerable diameter, so that the processes taking place in the inside of the cells are very easily observed under the microscope, and thence enable us to ascertain exactly how the cells of plants increase in number by dividing.

A common group of Confervas, called *Spirogyræ*, have the green colouring matter in the form of one or more spiral lines or bands lying upon the inside of the wall of the cell. When we place one of these filaments under the microscope, we see the cells (which are of the shape of the stones in a column) adjoining

end to end and firmly fixed together. The wall of the cell is coated inside by a thickish fluid in which fine granules float, which fluid lies like a sheet of jelly on the wall. It may be made to contract and solidify by applying spirits of wine, drawing itself up into a more or less regular mass in the centre of the cell, and at the same time bringing away the green band from the wall. Chemical tests show that this internal thickish fluid is of different composition from the membrane forming the wall of the cell, being of a nature more allied to animal substance; and it appears to be enclosed by a soft and gelatinous layer, which, during the life of the cell, forms a lining to the outer cell-membrane, but if contracted, as when spirit of wine is applied, shrinks up, and necessarily crowds together all the rest of the contents of the cell within it. The thick fluid is called the "*protoplasm*," meaning the *original substance out of which the organs are made*, since all the solid parts are formed out of this. The gelatinous layer which bounds it is called the *primordial utricle* of the cell, because it is the first structure that exists, but the term *formative layer* will be simpler and better for us.

Having made acquaintance with these structures inside the cell, which exist in all young cells, and remain as long as they retain the power of increase, we can now understand how cells divide. The filaments of most Confervoids grow by simply increasing in length, which is effected by the cells dividing crossways in the middle, each half growing to the length of the parent. In the *Spirogyræ* and other kinds the mode of the divisions has been accurately traced. The lining of the cell-membrane, the *formative layer* with the *protoplasm* inside, becomes gradually parted into two portions, just as if a string had been twined round it and was gradually pulled tight, as when a rocket-case is "choked." This produces a fold in the place where the division takes place; the *formative layer* when half divided may be compared to an hour-glass, and when quite divided it forms two bags instead of one, the new ends of the two bags being in contact. While this is taking place, the whole outer surface of the *formative layer* produces a sheet

Fig. 7.



A, a Cell of *Spirogyra* dividing into two by the formation of a partition. *B*, the same, treated with tincture of iodine to coagulate the "protoplasm." Magnified 250 diameters.

of firm substance of the same nature as the outer cell-membrane, and thus the two new bags which it forms become encased in proper firm coats, which render the walls of the old part of the cells thicker, and form a double partition at the part where the division took place.

We now see how the cell of the *Protococcus* divides into four, and how the multiplication of cells generally is effected. The cell of *Protococcus* is filled with *protoplasm* (containing green colouring matter). When the cell is about to divide, this *protoplasm* breaks up into two or four portions, each of which coats itself with a new membrane, and thus becomes a cell. As these grow, they are, of course, at first confined by the membrane of the original cell: this either stretches, dissolves away, or cracks and peels off, in different plants. In *Protococcus* it dissolves; in a little plant of similar nature, called *Schizochlamys*, it cracks and falls off. In ordinary vegetable substances it expands, being stretched by the swelling of the new cells within, until it becomes so thin as to be invisible. Thus, in the *Spirogyra* before mentioned we may trace the successive encasings of the cells, the oldest membrane, stretched by the growth of the new cells within, becoming gradually so thin that it cannot be distinguished.*

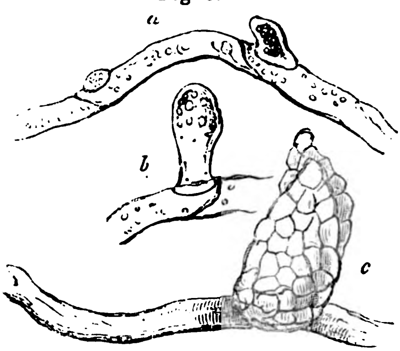
We have said that all growth of plants takes place by means of the division of cells in this way. In ordinary cases the new cells are consequently at first of the shape of a segment of the old one; but in certain structures this is somewhat modified, or at all events the old cell, when dividing into two, may produce two dissimilar cells. This takes place in the formation of free cellular structures, such as the branches of cellular plants, the formation of hairs, &c., and in the increase of number of a few plants. Thus, in the branching of some Confervoids, and of the filamentous structure growing from the 'spores' of Mosses, the parent cell grows out at the side, and then this lateral process is shut off as a new cell. In the growth of the yeast-plant the new cells bud out from the sides of the old ones, and are at length shut off and detached. (Fig. 9.)

Moreover, cells are in certain cases developed in a manner slightly different from that above described, namely, in the formation of the cells which are to produce new separate plants; but it is only by a modification of the foregoing process. In that the whole contents of the cell became parted into two or four portions to constitute the contents of two or four new cells.

* This encasing of the cells is beautifully illustrated by what occurs when we allow dead filaments of *Spirogyra* to remain in water. As the firm coat decays from without inwards, the laminæ are successively dissolved, and the filament breaks into strings of eight, then of four cells; these fall into pairs, and finally the youngest generation remains alone in the state of single cells.

In the formation of the cell which is to be developed into the rudimentary plant (called the *embryo*), in the seeds of all flowering plants, only part of the contents of the parent-cell are used for the new cell; a small quantity of the protoplasm is gathered up into a little ball at one end of the large parent-cell, and, acquiring a membrane, lies as a little loose bag there for some time, and then begins an independent course of growth: so that the new rudimentary plant is not fixed in any way but only *enclosed* in the seed.

Fig. 8.



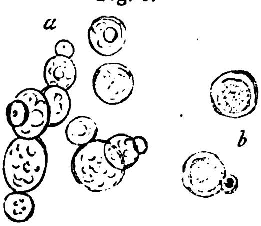
Fragment of the confervoid substance developed from the spores of a Moss, showing the mode of origin of a leaf-bud, from a branch-cell of the filament, magnified 200 diameters. *a*, *b*, *c*, fragments of the filaments, showing successive stages of growth; in *c*, the leaf-bud is formed.

We have dwelt at length upon these points, because they are of the highest importance in vegetable physiology. The knowledge of the dependence of the process of growth upon the gelatinous lining of the cell (the *formative layer* or *primordial utricle*, and the *protoplasm*) explains at once the influence of manures containing animal matter, or other nitrogenous substances. These contents of the cell are the really active living structure, which resides in the outer membranous case like a mollusk in its shell, and they are composed of substances closely analogous to animal matter; in fact, are the parts composed of albumen, fibrine, caseine, gluten, &c. The activity of the growth of a plant depends mainly upon the free supply of nitrogenous substance for the increase of this protoplasm. Plants can indeed appropriate nitrogen from the ammonia, and perhaps *directly* from the air of the atmosphere in their natural state; but the effect of increased supply of nitrogenous food is most strongly marked in all plants brought under cultivation. The influence of nitrogenous manures can scarcely be questioned by any who is accustomed to observe their effects upon the esculent vegetables cultivated for the markets of London and other large cities. By the help of organic manure and contrivances to increase the heat or prevent the cooling of the soil, vegetables are made to grow even to some extent independently of *light*, which we know to be of prime importance to vegetation in a state of nature. That plants can grow independently of light the botanist already knows, from the phenomena so familiar to him in the vegetables of the class of Fungi; and it is most important to bear in mind, when considering this

department of physiology, that those plants, the Fungi, growing naturally under conditions as to heat and light analogous to those by which we produce the unnaturally luxuriant and succulent growths in such vegetables as seakale, celery, &c., are characterized perhaps most strongly by the fact that they are nourished exclusively upon dead or living organic matters. Let us examine the facts that have been satisfactorily ascertained with regard to the composition, growth, and general vital phenomena of one of the Fungi.

The Yeast fungus, forming, as collected in masses, the substance known as yeast, consists of a microscopic sac or cell, such as we have already described. The individual plant is a globular vesicle, the membrane of which is composed (Mulder) of a "substance nearly approaching to cellulose in its properties and composition;" in fact, differs in no important respect from the substance forming the cell-membranes and hard parts of plants in general. This membranous sac, however, contains a substance of different composition "related to proteine" (Mulder). By the microscope we ascertain that this internal substance represents the *protoplasm* mentioned as filling the cell-cavity in Protococcus, and that it exhibits a dense layer where in contact with the cell-membrane, exactly corresponding to the "formative layer" above described. In short, the yeast-fungus is simply a Protococcus-cell, without the green colouring matter. The yeast-fungus grows by new vesicles budding out from the surface, into which a portion of the proteinous or nitrogenous contents is simultaneously transferred, and then the communication is cut off by secretive formation of cellular membrane by the "formative layer." Such budding takes place very rapidly and at various points of the surface when the yeast-plant is well supplied with appropriate food, and what is called *fermentation* in beer, &c., *depends entirely* upon such multiplication of the cells of yeast, the alterations in the fermenting liquid resulting from the chemical changes connected with the "digestion" or "respiration" of the plants. Now we know from microscopic observation that the formative layer is the prime agent in the processes of development and growth of cells as above explained in Protococcus and the filamentous Confervæ, and it is the same here. We know on the authority of Mulder and other chemists, that fermentation will not go on unless a certain supply of nitrogenous food is afforded to the

Fig. 9.



Group of cells constituting the vegetating form of the 'Yeast-plant,' magnified 800 diameters. *a*, groups growing by budding of the cells; *b*, cells (the lower budding) treated with tincture of iodine, which coagulates and contracts the protoplasm, leaving the outer wall free.

yeast-plant, and that the cessation of fermentation in the ordinary course of natural operations is the result of the consumption of the available nitrogenous ingredients of the fermenting liquids. If we remove a small portion of yeast from a fermenting wort, wash it and place it in a solution of *pure sugar*, it will grow but for a little time, until its *own* nitrogenous matter is consumed in the "waste" which takes place in cell-division. The new cells dwindle in size and their growth is soon arrested. By supplying nitrogen, on the other hand, the growth may be kept up until all the sugar disappears.

During the growth of the yeast-fungus, it is this nitrogenous formative substance in the interior which carries on the processes of nutrition and growth; as it elaborates the food imbibed in a liquid form through the cell-membranes, it increases in bulk and pushes out the wall into buds, supplies them with their proportion of "protoplasm," and throws them off. It is found, moreover, that the protoplasm gradually passes entirely into the progeny of bud-cells, and the old parent cells are left as empty collapsed sacs.

There is no reason to question the propriety of extending our conclusions from the yeast-fungus to all other plants of that class which live in essentially analogous conditions. And the construction and character of the substance of Fungi, thus fed upon organic matter, is quite in harmony with the gross, watery, and perishable substance which is produced by the growth of the higher plants when over-fed with nitrogenous manures. and at the same time limited in their supply of light and air. We may further extend the same set of conclusions to the early growth of shoots from germinating seeds and tubers (like the potato), where the protoplasmic substances at the growing points, when stimulated by heat and moisture, commence and carry on the cell-development without the aid of light, and produce from the store of organic food laid up in the old tissue, soft succulent growths, and continue to develop in the same way if supplied with nitrogenous food and abstracted from the influence of light.

The remarks contained in the foregoing paragraphs afford an explanation of the undoubted fact that plants cannot grow without a supply of nitrogen in some form or other, and that increased supplies of nitrogenous matter act upon vegetation as a stimulus; for we have seen that the vital part of the structure is not the more solid and permanent cellular substance of the ternary compounds destitute of nitrogen, but the *formative substance* contained in the cellular chambers, the *protoplasm*.

In these inquiries, however, we have left out of view the influence of the most important of the external agents concerned in the development of plants, namely, light. We have noticed

that the growth occurring in the absence of light produces weak, watery textures, while the supply of light, *cæteris paribus*, is marked by a corresponding solidity and vigour of the development. We might figuratively say that plants supplied with water and nitrogenous food, and withheld from light, are like animals fed on substances deficient in nitrogen, which, as is often seen in badly-fed children, results in unhealthy fat and want of vigour—since in animals the ternary compounds are applied more especially to purposes of respiration or formation of fat, while the nitrogenous compounds are required to form muscle and solid structure. In plants the water and nitrogenous food seem to favour expansion and development of new structure, while carbon, which apparently can only be assimilated by the help of the sun's rays, is the great element of the solid substance.

Nevertheless, the nitrogenous part of the plant, the formative protoplasm contained in the cells, still maintains its place as the living substance, when we endeavour to follow out the changes, anatomical and chemical, taking place under the action of light. If we examine into the cause of the green colour assumed by the leaves and stalks of plants when exposed to light, we find it to reside in granular structures or substances belonging to the protoplasmic cell-contents, which assume a green hue in consequence of a chemical change effected through the agency of light. The nature of this change is still unknown, but that the chlorophyll consists of the protoplasmic matter coloured green, is certain. Under a prolonged action of the chemical influence of light the protoplasm goes on to secrete starch-grains, the more solid form of assimilated matter of ternary composition, and the production of the *lignine* (woody) condition of cellulose, the substance which forms the hard cell-walls, giving to the originally succulent tissues the firm character of wood, is a result of the modification of the secreting action of the protoplasm dependent on the influence of light. The chemical actions which must occur in these changes are at present very imperfectly understood. It is only within a few years that the internal condition of the structures of plants has been thoroughly studied, and hitherto the chemical inquiries have been made, as we may say, "in the rough." The observations of Mulder on the yeast-plant are almost the only examples of a thorough examination of the details in such inquiries; in them the cell-membranes and the contents were subjected repeatedly to analysis, the comparative accuracy of the separation being ascertained by the help of the microscope, and the plants were examined microscopically in different stages of growth, while the chemical change in the medium and in their composition were ascertained by chemical analysis. But to apply similar researches to the higher plants, those growing in

the sun's light, and producing chlorophyll and starch, would be far more difficult, and it has not yet been seriously attempted. Probably the investigation would be most satisfactorily pursued in some of the simpler water-plants, such as the Confervoids above referred to, and this in particular because the microscopist has already ascertained the *anatomical conditions* in the successive stages of growth.

We know that green plants consume carbonic acid and evolve oxygen in daylight, but when we enter into the details of the chemical processes occurring here we find ourselves in complete obscurity, so great indeed, that it is not agreed among physiologists as to the use of the terms *respiration* and *digestion*, the process or processes which it is the chief office of green parts to perform. It is not our intention to enter now into a discussion of any of the other vital processes of plants, beyond the simple *vegetative reproduction*, dependent upon cell-development, above described. But as we have directed especial attention to the importance of the nitrogenous constituents of the tissues, we may mention one other point connected with this and with the processes of nutrition. The recent researches of M. Ville, and, *à priori* considerations, such as the reflection that animals are in the last resort all dependent on plants for food, render it extremely probable that vegetables assimilate nitrogen directly from the air. If so, it will probably be by the green parts, and hence the chemical changes occurring in the protoplasm of the cells of leaves will be even more complicated than has been hitherto suspected.

A knowledge of the ascertained facts of vegetable physiology leads to a recognition of our excessive ignorance, scientifically speaking, concerning the most important of the vital phenomena. Here, however, if anywhere, the motto "Science with Practice," should be adopted, for a large portion of the data of the science have still to be established by experiment: while the many crude notions that exist in the popular mind respecting the more obscure processes of vegetable life, render a kind of clearance of the ground necessary before the vast mass of "observing power" existing in our agricultural community can be turned to thorough account. It is our hope to present to the readers of the Society's Journal at a future period an account of anatomical and physiological researches on some of our most important cultivated plants, with a view of exhibiting the connexion of vegetable physiology with the practice of agriculture.

IV.—*A Report upon the Agriculture of the County of Durham.** By Thomas George Bell, LL.D.

Prize Report.

In a general view of the agriculture of the county of Durham there are so many points present themselves for consideration, all more or less closely connected with the subject, that it is difficult to condense the information, so as to express all that is necessary or useful within the limits set for this Report. This, however, I shall attempt to accomplish, and will only premise further, that nothing shall be herein stated which has not been matter of personal experience, actual observation, or information acquired from time to time during a long and extensive practice as a land agent.

General Characteristics of the County.—These are altogether of a varied nature, whether we look at the surface, the strata, the climate, or the inhabitants. In the surface there are great inequalities. There are no great mountains, as in some districts, nor large level plains as in others; but in every direction we have hills of gentle acclivity, intersected by broad valleys; the average inclination of the whole being an ascent from the sea, which borders the county on the east, up towards that range of internal mountains which runs along part of the borders of Scotland, and through England as far as Derbyshire. This county does not, however, rise up to the full height of this range of mountains, but stops short at a spot called Kilhope Law, in the midst of as desolate and bleak a moorland scene as we could possibly look upon.

In respect to the strata, we have not, as elsewhere, great bodies of the primitive rocks lying with something of their original regularity, but throughout nearly the whole county we have the disjointed and upheaved masses of the coal formation.

In the south-east corner of the county there is a tract of the new red sandstone; adjoining to it on the north and north-west there is a range of the magnesian limestone. It enters the county from the south at Winston, and runs diagonally across it by Selaby, Morton, Eldon, Merrington, &c., to the sea-coast at Hartlepool, from whence it proceeds along the coast to South Shields. All the county south and south-east of this limestone is on the new red sandstone, and the whole of the central portion of the county lying to the north of it is on the coal-measures.

Throughout the whole of the western or moorland portion of

* It may be only right to state that this Essay was written and received the prize in 1854, and that some portions of it have been omitted.

the county, mountain limestone prevails, and in the same district are those numerous veins of lead which have produced so much wealth to their proprietors, and furnish still the subsistence of nearly the whole of the inhabitants of the district.

The climate of the county is very uncertain and variable. In the sheltered valleys it is often some degrees warmer than in the more elevated regions, and the mean temperature appears to be reduced in proportion as we leave the sea-coast. Amongst the moors of the Teesdale and Weardale districts the winters are generally very severe and of long continuance. The mean temperature of the county, during the several months, is as follows :—

January ..	33·2°	July	58·3°
February ..	40·5	August	54·0
March	40·6	September ..	53·2
April	43·6	October	47·6
May	55·5	November ..	40·9
June	55·2	December ..	40·1
Whole year	46·9		

It will be observed that the greatest heat is in the month of July. That temperature frequently does not last long, and is often reduced by wet weather or prevailing east winds; and hence the more than ordinary risk which the farmer has often to run in this county with his corn crops. These crops are the natives of a warmer climate, and they take all the heat which our changeable one will afford them to ripen and bring them to perfection; and when the mean temperature of July is brought down by one or two degrees, the effects are at once seen both in the *quantity and quality of the crops.*

The elevation of the county at the highest part of its western boundary has been estimated at about 3000 feet above the level of the sea. As I have already observed, there are no hills within the county of very great height: the highest is Collier Law, 1680 feet, and the next Pontop Pike, about 1000.

The population of this county was—

In 1801	149,384
1831	253,700
1841	324,284
1851	390,997

I have not been able to ascertain the extent of the agricultural separate from the colliery, manufacturing, and trading population.

In the two divisions of the county there are 2064 voters on the Register of Electors, who are qualified by the occupation of land of the value of 50*l.* and upwards per annum; but this gives us a very inadequate idea of the number of farmers in the

county, because there are a great number of tenancies of a less amount than 50*l.*, and there are also a large number of individuals farming their own lands, whose names are placed on the registry as owners and not as occupiers. I cannot pretend to give more than an approximate estimate of the area of the county, where the different statements on the subject have been so contradictory.

	Acres.
By Mr. Bailey, in his Report on the Agriculture of the County, it is said to contain	582,400
By Mr. Surtees, in his History of Durham	610,000
By the last population returns	622,476

From calculations I have made upon the best published map of the county, I am of opinion that Mr. Bailey's estimate may be taken as a correct one, if meant to express the area of the agricultural parts of the county, leaving out the acreage of the large towns, which are evidently included in both the other estimates.

The rental of this county in 1815 was	£791,359
" " 1840	905,644
" " 1853	1,148,096
Showing an increase between 1815 and 1840 of ..	114,285
And between 1840 and 1853 of	242,452
Total increase	£356,737

I am not, however, in possession of any correct data from which to apportion this increased rental, between the improved value of the lands and an increased amount of houses and buildings applied to other than agricultural purposes.

In the basis for the county-rate, which is the rental of the several townships throughout the county, it is very difficult to estimate the portion of the rental derived from the land, distinct from that derived from collieries, manufactories, buildings, tithes, &c.; but I have gone through each township with what local knowledge I possessed or information I could obtain, and have estimated the rental of the land at 459,000*l.*; hence, taking 582,400 acres as the contents of the county, we obtain 15*s.* 9*d.* as the average rent per acre over the whole county.

But as this is rather an interesting subject of investigation, I have endeavoured to arrive at a similar or more detailed result by another mode; and though I must confess to having very imperfect data upon which to found my calculations, yet, after bestowing much pains on the comparing of valuations, and the forming of averages in several districts, &c., I would venture to present the following as a somewhat near approximation to the truth:—

Acres.		£.
92,800	of moorland, let on an average of 4s. per acre	18,560
71,500	occupied by woods, wastes, roads, rivers, &c. Much of this is included in the acreage of the farms; therefore, say on an average 6s. per acre	21,450
106,960	of old grass-land in the lowland districts, let on an average of 15s.	80,220
311,140	of tillage lands, let on an average of 19s.	295,583
582,400 acres.	Rental	£415,813

Soils and their Rent Value.—The great variety of soils to be found in this county may be accounted for upon a little acquaintance with the varied character of its stratification and the irregularity of its surface. Hence, I have seen large tracts of land in this county where there was very little depth of soil covering the shale and hard shivery sandstone, which so often accompanies the coal, and here there was little to encourage the agriculturist. No corn crops would grow, and the herbage, which barely covered the ground, was scarcely worth the pasturing. We find it quite different on the elevated portions of some of the limestone; there we have a soil, not deep, but light and dry, and capable of producing a good cover of grass. The irregularity of the surface of the county has still more largely promoted a variety of soils, for it has promoted an endless variety both in the depth and quality of that alluvial deposit by which the subjacent strata are covered. Accordingly, we find that in all the valleys and hollows throughout the county the soil is deeper and more productive than on the more elevated portions; though even there its quality is very different, according as the situation has tended to promote the deposit of silt and vegetable matter brought down by the action of water during the course of years. By the side of the three principal rivers —the Tyne, the Wear, and the Tees—there is a good extent of flat or "haugh" land of a good loamy character. From the mouth of the Tyne, by Jarrow, Hebburn, and Heworth, to Gateshead, and from thence up the Ravensworth Vale, we have strong soil on a stiff clay subsoil. I dug a tank in this district not long ago, and after 2 feet of vegetable soil we went through 6 feet of stiff blue clay which cut like leather. Notwithstanding this, the surface, where drained, is very friable; it is generally a good wheat-soil, and by proper management is, in many parts, made to produce excellent crops of turnips. A farmer in the Hebburn district tells me that the average produce of wheat there will be 20 bolls an acre, but that with proper draining and good management the district would produce more. Along the seacoast, from Whitburn to Hartlepool, the greater part of the soil is lighter, being on the limestone, with a gravelly subsoil. In parts of that district it has become richer by good management,

yet the most of it is poor. On this range we have Dalton-le-dale, about 800 acres, let on an average of 13*s.*; Hawthorn, 1500 acres, on an average of 15*s.*; and lands near Easington, about 6000 acres, let on an average of 19*s.* per acre. Continuing by the coast, after passing Hartlepool, we get on to the red sandstone, the easternmost portion of which is a mellow loam, partly on gravelly subsoil. Of this there is about 13,000 acres, extending from Greatham and Claxton round by Newton Bewley and Wolviston to Port Clarence, worth on a general average of the whole 20*s.* per acre. Of the interior portions of the county, lying to the west of the districts just referred to, it is more difficult to give a correct idea, as the good and bad land is still more irregularly distributed. Proceeding westwards from Hartlepool, we have first the Elwick district, where a large proportion of the land lets on an average of 19*s.*; then Morton, averaging about 21*s.*; next (keeping direct west) we have Hollin Carr and other grounds, a great deal of which is not worth more than 10*s.* South-west of them we have the Sedgefield district, let on an average of 25*s.*, most of it strong but friable—good potato and turnip land, and very capable of being raised to a higher average by judicious draining. That portion of the Sedgefield district which lies round Hardwick Park has been much improved by draining and good management. The whole of the district I have referred to as lying to the west of Hartlepool is on a clay subsoil of different degrees of tenacity, the strata beneath being the new red sandstone. A short distance to the south-west of Sedgefield is a tract of land, called Morden Carrs, containing about 3000 acres, which Mr. Bailey refers to in 1809 as being then of little value, but which he says, "if properly drained, would in a few years be worth three pounds an acre." Not a *few* only but *forty-five* years have passed away since that opinion was expressed, and Morden Carrs still remains in its undrained and almost valueless condition. It is all in grass, and, though some improvement has been made by cutting open stells, it is still very often covered with water, though it might apparently have been easily drained into the river Skerne, which runs through it: the soil is a deep peat. In the construction of the York and Newcastle Railway, that part of the line which runs through this ground sunk and the rails disappeared; and they say in the neighbourhood that rods 30 feet in length were put down without arriving at sound ground. To the south of Sedgefield and Morden there is a district of a deeper loam, but not rich, and still on a clay subsoil. This includes Bishopton, Stainton, Redmarshall, Sadberge, &c. Continuing to the south, we come to another tract of land, comprising the westernmost portion of the red sandstone. Here the soil is stiffer, being on a strong clay. There are also evident signs of water hanging in the rock

beneath, and deep draining might be expected to make great improvement. This district comprises the townships of Sockburn, Dinsdale, Hurworth, and Neasham, and there is of it about 6000 acres, averaging in value about 28*s*. The clay subsoil, with little exception, surrounds the town of Darlington, and from Hurworth continues towards the west until it reaches the river Skerne. This river, at the point where it enters into the river Tees, as well as for some distance northwards, seems to divide the strong clay lands of Hurworth and Dinsdale from the light gravelly soil prevailing about Coniscliffe, Carlbury, Pierce Bridge, &c. Of the last mentioned there may be about 4000 acres, averaging 21*s*. an acre. The soil from here to Barnard Castle for a limited breadth from the river Tees is a richer loam, which in some places is worth 30*s*. an acre; but the soil becomes thinner and of less value as we leave the river and ascend the rising ground towards the north. At Archdeacon Newton and around that place we have from 1200 to 1400 acres, averaging 18*s*. an acre. Beyond that we have a stripe of land of better quality, reaching from Whessoe by Denton to Killerby, perhaps about 3000 acres, averaging 28*s*. or 29*s*. To the north and north-east of Barnard Castle we have the Raby estates, belonging to the Duke of Cleveland, and Streatlam, belonging to John Bowes, Esq. On both estates there is a great variety of soils and values. Upon the Duke's estates there may be from 3000 to 4000 acres, averaging 20*s*. an acre. At Cockfield, which lies to the north of Raby, and from thence to Woodland, there is a tract of poor shallow soil, lying partly on the shale and partly on the millstone grit of the coal formation. In this district there is about 5000 acres, worth on an average no more than 9*s*. per acre. I trace the same poor unproductive soil across the whole county, from the district just alluded to up to its northern boundary. It lies along the whole eastern boundary of the limestone of the mining district, and seems to form the more elevated portion of the coal formation, upon which there has been the smallest share of alluvial deposit or vegetable soil; indeed in many places the shale and sandstone "crop out to the day." It may be interesting to put down a few of the townships which comprise this tract of barren land, with their estimated acreage and rental:—

Townships.	Acreage.	Rental.
Cockfield and Woodland	4,416	.... £2,203
Langley Dale	4,685	 1,972
Lynesack and Softley	5,946	 2,793
Hamsterley	4,003	 1,590
South Bedburn	6,765	 1,639
Muggleswick	7,098	 1,738
Acres	32,913	£11,935

Or upon an average 7*s*. 3*d*. an acre.

The lead-mine district, which includes the whole of the county lying to the west of the tract of land just referred to, contains 78,190 acres, let upon an average of 3*s*. 8*d*. per acre. As this statement may perhaps appear incredible to some, I will mention four only of the townships in that district, with their acreage and rental :—

Townships.	Acreage.	Rental.
Middleton in Teesdale	10,434	.... £3,037
Newbiggen	4,627	 1,190
Forest and Frith	17,270	 1,366
Hunstanworth	10,380	 1,029
Acres	42,711	£6,622

Or an average of 3*s*. 1*d*. per acre.

The soil of the greater part of this lead-mine district is poor and thin, in places being composed of vegetable substances imperfectly decomposed. It presents us with large tracts of peat, in which we find every here and there, from want of draining, wet spongy flats, provincially called mosses or flows. Here all is wild and uncultivated. It cannot be called an agricultural district. The lettings are very small, and the moors not half stocked. The chief dependence of the inhabitants is upon the mines, and the care or cultivation of the land is with them a minor consideration. A horse to bring coals for the family, a cow to supply milk, or a few sheep, if he borders on the common, is all that the householder desires. The mining district is known by the two general names of Teesdale and Weardale, from the two rivers which run through it. The westernmost and highest portion of Weardale is of by far the least value of any land in the county. Kilhope and Welhope are the two westernmost branches of the river Wear, and the lands bordering on those two streams skirt round the boundary of the county. They form an estate held by lease under the Bishop of Durham, and contain about 3800 acres. This estate was let at one period for 135*l*. per annum, and was valued at the last renewal of the lease at 282*l*. 10*s*.

There are many portions in the interior of the county yet remaining to be described, but I shall be obliged to dismiss them in a few words. So far I have been describing the different districts we have gone through rather with the desire of illustrating the very varied character, quality, and value of the soils generally throughout the county, than with the hope of having space to complete a description of the whole county in a similar manner. I have only, then, further to observe, that in what remains undescribed the soil is equally irregular in its value. It will have been observed, I think, from my previous description, that the great bulk of the soil of this county is on a clay subsoil,

and that the thickness of soil covering the clay is of an endless variety of thickness and quality. Of gravelly or sandy subsoil there is only a small proportion, and it is scattered in various parts with much irregularity. I cannot form any correct idea of the respective quantities of each of those two kinds of subsoil; in fact, the distinction between them is not so completely marked as to cause farms to be managed (as in other counties) upon an entirely different system, according as each may be situate on the one or the other. The average values per acre in various districts over the whole county have been calculated from the best information it was possible to obtain—namely, from actual valuations; of which not less than 2415 have been carefully gone through.

Common Lands divided.—We shall do injustice to both landlord and tenant, if we form an opinion of the present state of the agriculture of any county or district, without bearing in mind what that county or district was in some former period, so as to ascertain the progress or improvement which has been made. I must therefore refer to the fact that, within a comparatively recent period, a large portion of this county was unenclosed and uncultivated, and lay either in wide tracts of desolate moor, or in more sheltered, though equally neglected, "stinted pastures." Mr. Bailey, in his Report on this county, gives a list of commons divided between the years 1756 and 1809, amounting to 114,071 acres. Since the last-named period the following additional commons have been divided and enclosed:—

	A.	R.	P.
Gilligate Moor and Town Fields	300	0	0
Beamish South Moor	478	0	0
Blackburn Fell	2,600	0	0
Egglestone Moor	5,987	1	3
Gateshead Fell	631	0	21
Gateshead Town Fields	158	1	0
Woodland, parish of Cockfield	2,260	0	0
Whickham Fell	451	2	16
Barlow Fell, Beda Hills, and wastes of the Manor of Winlaton	521	0	0
Middlehope Fell, Weardale	2,343	0	0
Middleton in Teesdale, in and out Fells	9,224	2	21
Boldon Common	63	2	14
Total	25,017	1	35

Thus we have an aggregate of 139,088 acres of common land divided between the years 1756 and 1853. I have examined the papers connected with a number of those divisions, now in my possession, and find that the average value per acre placed on those commons which were situated in the central and more im-

proveable parts of the county did not exceed 9*s*. Much of the same land, having been enclosed and brought into cultivation, is now let at prices ranging from 30*s*. to 60*s*. per acre. Many thousand acres of this common land, lying in the less improveable parts of the county, did not average more in value, in their unimproved condition, than from 4*d*. to 10*d*. an acre. The fee-simple of one allotment of 775 acres was sold for 820*l*., and the fee-simple of another, containing 1000 acres, was valued at 750*l*. I cannot say that this portion of the common land has been improved in anything like the same proportion as the more improveable commons. Still, many patches by the sides of rivers, &c., have been picked out, and made into good pasture land, and some has been brought into tillage. But the great want has been draining and extensive planting for shelter; and, if I am asked why this has not been accomplished, I must refer to the remarks I shall shortly make on church leasehold property, the greatest part of the moors now under consideration being of that tenure. Mr. Bailey calculates that, of the commons divided previous to 1809, 40,000 acres would not pay for cultivation; and that 74,000 had been enclosed, divided into fields, and brought under a regular system of cultivation. Of those divided since, one-half the quantity has been also brought into cultivation. So that we have in all, by those divisions, 86,508 acres of ground, formerly lying dormant or almost valueless, brought into cultivation, and raised to an average value of about 18*s*. per acre. If we had no other improvement to notice in respect to the agricultural state of Durham, this alone would be sufficient to excite our attention and satisfaction. Before leaving the consideration of this point, I may allude to the case of a small portion of land, part of one of those commons, which may serve as an illustration of the improvement effected by their enclosure. The land in question was an allotment of about 8 acres, about one-half of it being valued at 2*s*. 6*d*. and the remainder at 5*s*. per acre. It had on it little herbage, indeed none of any value, but was principally heath and coarse grass interspersed with bushes of whin. The first operation was the draining. This was done effectually by drains 30 inches deep and 8 yards apart. I often wonder at the tenacity with which drainers hold to their favourite systems of deep or shallow draining, as if either system would serve as a fixed rule, to be alike suitable in every locality and under every circumstance. My first object of inquiry, on looking at any land requiring draining, is to ascertain whether the water is an outburst from the strata beneath, or merely the rain hanging in the ground for want of outlet. If it is the first, we must of course go deep to catch the springs; if it is the latter, shallow

draining will answer in nine cases out of every ten.* In the present case shallow draining reached all the requirements of this enclosure, and we next had the whole of the surface pared and the sods burnt. Lime was next laid on, and the whole ploughed in. This was done in the autumn, and the ground lay over the winter. In spring it was ploughed again, oats sown on it, and well harrowed. Four bushels an acre were sown broadcast, and the produce was about 54 bushels an acre. The next crop was potatoes, well manured, of which there was also a most satisfactory crop. This was succeeded by wheat sown down with seeds, the land being intended for permanent pasture. In its present condition it is equal to any grass-land in the county, and lets for 4*l.* an acre.

The working of the Minerals an obstacle to the improvement of the surface.—Before proceeding further into my subject, I may be allowed to point out the great obstacle to the improvement of agriculture or the cultivation of the surface of this county, which arises from the immense wealth which has been, and still is, derived from the minerals beneath. No other county is so interwoven with a network of public and private railways. In no other is there so large a quantity of land occupied by collieries, manufactories, quarries, waste heaps, &c.; and in none, perhaps, is there a more extensive trade carried on in the working, manufacturing, and sale of coal, limestone, ironstone, and lead,—all inducing a sacrifice of the interests of the surface for the sake of what lies below it. There is an enormous amount of trespass involved in all this trade. The pitmen especially are notorious for making roads for themselves in every direction, just as their necessity requires. Fences are destroyed, and crops are too often trodden down. This is disheartening to the tenant, but he begins to tolerate it when he finds that the collieries want to occupy a large portion of his land. Fresh heap-room is required, or it may be new waggon-ways have to be formed; and the farmer begins to grow careless of agricultural improvement when he finds, on the one hand, that all his improvements bid fair to be destroyed by fresh requirements of the colliery owners, or by the trespass of a reckless population around him,—or, on the other hand, that it is more profitable to receive his "double damage" from the colliery than to make increased efforts for the improvement of his land. The "double damage" referred to is double the rent per acre which he pays for his land, which the colliery owners are bound to pay him for the full quantity of it which

* If by shallow draining Dr. Bell means drains not less than three feet, the statement may be admitted. Three feet of soil above the water-level is required in all cases in which any draining at all is likely to do good.—Ed.

they may take, occupy, or damage. The landlord receives his compensation for all this hindrance to agricultural improvement, in the shape of heavy way-leave and other rents from the colliery owners.

Size and Tenure of Estates.—A large portion of this county is held in small properties, and many of them are frequently changing owners. There are 12,370 names on the Registry of Parliamentary Electors in this county; and if we take away the tenant voters and the voters whose qualifications are houses or buildings alone, there must still be left about 4000 individuals amongst whom the land of the county is divided. Bailey mentions two estates of from 20,000*l.* to 22,000*l.* per annum; three from 12,000*l.* to 14,000*l.*; two from 7000*l.* to 8000*l.*, &c. I have now before me the rent-roll of one estate producing 8680*l.*, and of another producing 6400*l.* per annum; but there are not many of such sizes. In a list of estates which we have had for sale within a short period there have been,—

1	between	2000	and	3000	acres.
1	„	700	„	800	„
1	„	400	„	500	„
11	„	300	„	400	„
15	„	200	„	300	„
22	„	100	„	200	„
27	containing less than 100 acres.				

A large quantity of the land is of leasehold and copyhold tenure held under the Church. The following is the average of three years of the annual income the Church derives from this property in the shape of fines on the renewal of leases, reserved rents, &c.:—

Bishop of Durham	£21,991
Dean and Chapter	35,071
The Dean and Prebendaries in severalty ..	14,342
The Archdeacon	27
	£71,431

The annual value of the second property alone, viz. that held under the Dean and Chapter, has been calculated at 100,000*l.* if let on rack-rent; and this sum is thus divided:—Land, 64,000*l.*; tithes, 10,000*l.*; mines and minerals, 26,000*l.* The lands belonging to the Bishop are let on leases for lives, and some upon terms of 21 years; those belonging to the Dean and Chapter, on leases for years, the terms being 21 or 40 years. The practice has been to renew at the end of 7 years in most cases, though there are others where the renewal takes place at the end of 4 years, and a few cases renewed each year. The property of the Dean, and of the several Prebendaries and the Archdeacon, is let

at rack-rent. The manor of Westoe is held under the Dean and Chapter, and so was a great portion of South Shields; but a few years ago, under the authority of parliament, on the establishment of the University at Durham, they enfranchised property at that place by which they realized above 48,000*l.* It was wished to have raised 95,000*l.*, but many of the lessees refused to accept the terms. The valuable manor of Gateshead is leasehold under the Bishop, held for 21 years, a renewal being made each year. The manor of Whickham is copyhold, also under the Bishop. Large portions of freehold lands, however, lie in detached parcels within these two manors. I have felt it necessary to refer more at length to this property, because I believe that the nature and extent of it has been for many years a great bar to agricultural improvement in this county. This fact has been more than once proved, by the evidence of impartial and competent witnesses, before Committees of both Houses of Parliament. The buildings on this property are almost invariably of an inferior description, and include no more than will barely suffice for the occupation of the land. The ground is just in a similar condition in regard to draining; indeed no man having this species of property, and aware of the manner in which the fines on renewal are made to rise in proportion to all improvements, would think of laying out more money on his estate than he could not well avoid. But one particular by which these lands may be readily distinguished from all others is their being almost universally destitute of trees. This is owing, no doubt, to the stringent reservation in the leases of "all woods and underwoods." In some parts of the county there are thousands of acres of land which would have been planted if it had been of freehold tenure; but on this kind of property, if the lessee planted a thousand acres he could not cut down a single tree when grown up for his own use without the leave of the lessor; and the consequence is, that many a bleak hill remains unplanted, and many a cold farm remains unsheltered. The advantage to be derived from extensive plantations has been repeatedly pointed out. Over a great deal of the poor land of this county it has been shown that, if 20 acres were planted out of every 100, the remaining 80 would, in a few years, be equal in value to what the 100 used to be; and, in addition, there would be the 20 acres of wood rapidly coming into a saleable state of growth, in a district where the numerous collieries created an almost unlimited demand for all kinds of timber. Thus the estates would be increased in value more than 20 per cent. There is an increasing want of confidence in this property. A 21-years lease at one time would produce 18 years' purchase; of late years much has been sold at 16 or 17; and within the last two or three years, since the subject was so much

under discussion both in and out of parliament, it has hardly been saleable at any price.

By an Act, 14 and 15 Vict. cap. 104, this church leasehold property was permitted to be enfranchised during a certain period; this period is just about to come to a close, and it appears that not above a dozen parties in the county of Durham have availed themselves of this opportunity, although the number of lessees will amount to many hundreds. This is not supposed to have been caused by a desire for the continuance of such a tenure, but rather from an idea that the terms of enfranchisement were unfavourable towards the lessees.

Size of Farms.—Not only is the county divided into small properties, but even the few large properties in it are divided into small farms. By far the greatest number is under 200 acres. A list of 575 farms which have been to let within the last few years is thus divided:—

Above 2000 acres	2	Between 300 and 400 ..	24
Between 1000 and 2000 ..	2	„ 200 „ 300 ..	74
„ 700 „ 800 ..	3	„ 100 „ 200 ..	190
„ 600 „ 700 ..	3	„ 50 „ 100 ..	142
„ 500 „ 600 ..	3	Under 50	121
„ 400 „ 500 ..	11		

The question of enlarging the size of farms in this county, by adding two or three of the smaller ones together, has often been discussed. Some argue that farmers of greater capital would be procured, and the land generally managed with greater spirit; but on the other hand it is urged, with great appearance of truth, that men of capital like better soil than that of which the greater part of the county is composed; and it has been much questioned whether the landowner might not have to run greater risks of loss of rent by larger farms than he now does with his small ones, on which, if he has tenants of small means, he has generally men of industrious habits, who are always struggling on to pay their rent and maintain their families. Undoubtedly, however, this is one of the causes of the "backward condition of agriculture in Durham," that the farmers generally on the small farms are deficient in that capital which is necessary to carry them on, according to new and improved modes of management.

Causes of backward condition of Agriculture in Durham.—I may now be allowed to recapitulate what has appeared, from the statements already made, to have been obstacles to the improvement of agriculture in this county:—

1. The larger than ordinary proportion of poor unproductive soil.
2. The extent of land remaining in an uninclosed and "intercommon" state up to a comparatively recent period.

3. The wealth derived from the minerals causing in many places a sacrifice of the surface for the sake of what lay beneath it.

4. The prevalence of small properties, which are frequently changing hands, as well as the large extent of land of leasehold and copyhold tenures, under which there was not sufficient encouragement to improvement.

5. The small tenancies into which most of the land is divided, together with the want of capital so general amongst the tenants.

Conditions of Letting.—The great majority of the farms are let from year to year. There seems a great prejudice against leases, as much amongst the tenants as the landowners, though some see an advantage in them, and leases are granted on some estates for various terms, principally three or seven years. The usual time of entry is at May-day, and the rents are made payable half-yearly on the 23rd November and 13th May, though in most cases there is a period allowed for payment after the same becomes due. This is generally half a year, and is called the "running half year." The tenant on quitting has an away-going crop from off one-half of the lands in ploughing with the use of the stack-yard, barn, and granary for a certain period (as agreed upon) after the expiration of his tenancy; but he is bound to leave the straw for the incoming tenant, and must supply it to him as he needs it. In many cases the away-going crop is sold, and is often purchased by the incoming tenant.

The usual stipulations in agreements with tenants in this county are—Not to plough or break up any portions of the lands laid down to permanent grass.

To manage the arable lands according to the system of husbandry agreed upon.

To keep and leave in good repair all fences, gates, drains, &c.

Not to sell any hay or straw from off the farm without bringing thereon in lieu thereof five fothers of dung for every ton of hay or straw so sold.

Not to depasture in the last half year a greater number of stints than in the previous half years.

To permit the incoming tenant previous to the expiration of the tenancy to sow with grass-seeds the lands sown with the away-going crop, and to roll in the same; and also to scale and dress meadow grounds; also to place lime or manure on some convenient part of the premises for his own use.

To lead all materials which may be required for the repair or alteration of the farm-buildings.

To pay, in addition to the rent agreed upon, 5 per cent. on the landlord's outlay in draining any part of the farm.

The landlord reserves to himself or his agent the privilege of

entering upon the farm at all seasonable times, in order to see that it is properly managed according to the agreed scheme of husbandry; and there is invariably a penalty specified of a certain additional rent per acre for every acre of the farm managed contrary to the stipulations or agreement.

System of Husbandry.—The system under which the greatest proportion of this county was managed at one time was that which has been styled the "Two Crop and Fallow System." The rotation then was—

1. Fallow. 2. Wheat. 3. Oats. 4. Fallow.	Or,	1. Fallow. 2. Wheat. 3. Beans. 4. Fallow.

Bailey mentions both of these rotations, and I have heard from various quarters that they prevailed to a great extent. They do not do so now. Draining and a more liberal supply of manure is enabling the farmers to introduce a better system, and this old one is all but extinct. There was much excuse for it while it lasted. The land was deplorably and universally in want of draining. Turnips were a rare crop. Artificial manures were unheard of. The farm-yard manures could not be had in sufficient quantities; for so little stock was kept that a sufficiency was seldom produced upon the premises. Lime was certainly to be had in some localities, but not in all; for in those days the roads all over the county were kept in bad repair, and railways had not been introduced. In reference to the railways, what advantages we possess now, in comparison to what the inhabitants of the county possessed so recently as 1809, when Mr. Bailey could say—"There are no iron railways used as public roads in this county"—a glance at the county map will show the great number there are now. The advantage of these railways is very great to the farmers of this county, both in enabling them to convey their produce to market, and in the more plentiful and cheap procuring of lime and manure.

The system of husbandry which now prevails is the four-course system, under which, as a general rule, the rotation of crops is made to vary much according to local circumstances—

On Light Soils.

1. Turnips, eaten off the ground with sheep.
2. Wheat, sown down with seeds.
3. Clover, either pastured with sheep or mown.
4. Barley or oats.

On Strong Soils.

1. Bare fallow. 2. Oats. 3. Seeds. 4. Wheat.

The above are frequently adopted. In regard to the rotation

on clay soils, I find a great difference of opinion in the county as to the comparative superiority of bare-fallowing, or the cultivation of green crops. The great arguments in favour of the bare-fallowing is—1, the stiffness of some of our clay soils, and the necessity of more frequent ploughings and better working than can be given with green crops; 2, the difficulty of procuring a sufficient quantity of manure; and, 3, the great tendency of our poor soils to produce weeds, which it is thought the green crops will increase. To this it may be said that the first objection would be overcome by draining and the use of clod-crushers and other modern improved implements; the second is a difficulty more in imagination than reality, for in practice it would soon be found to remove itself—cultivating green crops would enable the farmer to feed more stock, and keeping more stock would produce him more manure; to remove the third objection a little care and industry would suffice; and I may certainly say, that so far as my experience of the county goes, the lands on which green crops are most extensively grown are far cleaner than those which are allowed to lie every fourth year in bare fallow. Still there is a very general opinion that a great deal of the poorer clay soils in this county are not calculated to grow green crops; or as a shrewd old farmer said to me the other day, "all the draining in the world will not make turnip soil out of our stiff clays." But all are not of this gentleman's opinion, for not long after I met with another person, who declared that he never had a single acre of bare fallow, and that he got most excellent crops; they never failed, and he accounted for it by saying that he "had good implements, and put the ground into good heart by good manuring, for which he was fully repaid by good crops." His fields were all drained three feet deep and seven yards apart. I believe *draining* would settle the whole controversy. If the lands were all properly drained, there would be found very little even of the stiffest of our clays which would not soon break down and pulverise so fine as to be capable of growing turnips. It has been tried and (as I shall state more fully in a little) the experiment has answered. Turnips are grown where they never grew before; and not only would turnips be produced in soil now thought unsuitable, but by draining we should soon see the average produce of all kinds of crop increased. A farmer stated not long ago at a public meeting of the Darlington Farmers' Club, that it was his opinion that the bulk of the land between Darlington and Newcastle, which was now yielding from 20 to 25 bushels of wheat per acre, would, if properly drained, yield, with less labour and expense, from 30 to 40 bushels.

Upon the Duke of Cleveland's estates at Raby (before alluded to) there are some farms in excellent condition. They lie around

the town of Staindrop. The soil is loamy, and in general very productive. A large proportion of the land round about the town is in old grass for the use of the inhabitants. The tillage land is worked on the four-course system, and the rotation is generally—turnips, wheat, clover, and oats. The oat stubble is ploughed in November, and again in the spring, when from 20 to 25 loads of dung per acre is laid on, or a proportionate quantity of bone or other manure, and the turnip-seed is sown in drills. The quantity of seed varies according to the soil; 2 lbs. per acre may be an average. The average produce of the turnip crop will vary from 30 to 40 loads per acre according to the season. The turnips are either eaten off by sheep, or pulled and stored in pits for stall-feeding of cattle, &c. As soon as the turnips are off the ground, the land is again ploughed, and wheat sown; the quantity of seed 2½ to 3 bushels per acre. The average produce of wheat differs very much in various districts. On the poorer soils from 12 to 20 bushels. On the district of which we are now writing, it may be from 20 to 30 bushels. As soon as the wheat has received one harrowing after sowing, the grass seeds are sown. The quantity of seed varies from 14 to 16 lbs. per acre. When the grass is to pasture one year, there is generally sown 8 lbs. red, 1 lb. white clover, and half a bushel of rye-grass per acre. If it is intended to cut for hay, a larger quantity of seeds are given. The seeds remain for one or two years either mown or pastured, and are generally broken up before winter, and oats sown in February or March. The oats are sown broadcast. The quantity of seed is from 3 to 5 bushels per acre, according to the kinds, and the average produce from 40 to 60 bushels. The rotation on the lighter soils adjoining to the river Tees, west of Darlington, is generally turnips, barley, clover, and wheat. Most of the tillage lands in that district are drained and well pulverised. They produce generally an excellent quality of barley, with an average yield of from 36 to 42 bushels an acre. On the better class of soils, where many horses and cattle are kept, the clover is allowed to remain longer than on others—generally for two or three years. Perhaps sufficient pains are not taken sometimes to have the land in a clean condition, and well broken down when the seeds are sown; at least there are many cases where the clover comes up full of weeds; and there have been many more in this county lately, where it either does not come up at all, or "goes off" on the second year. I can reckon up six different places at which I have just seen the fields in course of being ploughed up because the clover had entirely failed. On such a thing taking place, the farmer endeavours to get another crop into the ground as early as possible. If it is the second year the clover fails, oats

are generally sown; if it fails to come away at all, beans or peas are occasionally put in. If the clover remains three years, it is generally mown one year, and pastured the other two. The fallow crop is varied according to locality. In the neighbourhood of the large towns large quantities of potatoes are grown. Tares, peas, and beans also occasionally form the fallow crop; the last named but seldom in this county compared with others.

Before leaving this branch of my subject, I may state that the charges which have been brought against the agricultural condition of this county have been—

1st. The abundance of weeds.

2nd. The extensive prevalence of bare fallowing.

3rd. The too rapid succession of corn crops.

To these I answer:—

1. The weeds are rapidly disappearing under increased drainage. By far the largest proportion of them consisted of "buttercups" and other bulbous and tuberose-rooted plants, which were a certain indication of water. There are now many farms in the county which, in point of cleanliness of the soil, may bear comparison with any farms in the kingdom.

2. There are some portions of our poor clay soils which, for some time at least, cannot be expected to grow turnips; but the quantity of them is reducing every year.

3. The regular "four-shift scheme," which is (with slight modifications) all but universal throughout the county, has been found most suitable to the character of our soils and local circumstances. Under this course the alternating of corn and green crops is regularly kept up. As to the "two crops and a fallow" system, about which so much has been said, I have already stated that it is almost obsolete; and it so happens that I can give the period when it began to become so. The following short extract may be interesting. It is taken from a letter dated June, 1794, and written by Mr. Silas Angus, land agent in this county to Sir William Appleby:—

"Agreeable to desire, I shall attempt to give you a sketch of some of the methods of husbandry practised in this neighbourhood. *The former practice* was two crops and a fallow; but for want of being changed, the land in tillage became tired of growing corn, especially oats. In order to remedy that inconvenience, a new system was established under a four-course shift, or what is here called '*four aders*'—viz., wheat, clover, oats, and fallow; and by that alteration great benefit was at first derived. As clover then was rather a novelty to the land in this quarter, it generally produced a plentiful crop, and was also the means of a good crop of oats succeeding it. But now the present mode of some places hereabouts is under the regulation of five aders, which is continuing the clover crop two years; and this was thought a probable means of greater improvement."

Permanent Grass.—The proportion of old grass land is in

some parts of the county much too small. In the neighbourhood of Gateshead, and up the Ravensworth Vale, there are good fields of old grass; but it is in the southern part of the county that the best meadows and pastures are to be found. In the Staindrop district the farms are nearly equally divided between grass and tillage. In other parts one-third only of the lands are in grass, and in some there is a still smaller proportion. Where the old grass lands are mown they receive a top-dressing of manure, generally about 15 cart loads to the acre. It is usual to mow and pasture an old grass field alternately. The average of the hay crop is generally 1½ tons per acre. The fog or aftermath is pastured. It is very common near the principal towns, where a number of milch cows are kept by the inhabitants, for the farmer to receive stints into his pastures. From 6*s.* to 12*s.* per week is paid for a cow, according to the season or condition of the grass. The quantity of land considered necessary for a stint is about 1½ acres, and it was usual to reckon the number of cattle a farmer should possess by the number of stints his pastures would carry; but this is no longer a criterion since stall or farm-yard feeding came so much into use. As I have frequently had occasion to point out that, in particular localities in this county, the proportion of permanent pasture is too small, I have been led to give some attention to the laying down of land to grass; and particularly to an endeavour to ascertain, in several instances, the causes which have led to a failure of the seeds. The grass seeds are almost always sown away with a grain crop; and it is not an unusual thing, soon after the crop of wheat has been cleared off the ground, to find that the grass will not be worth allowing to lie. The causes of failure have been, bad soil; the ground not sufficiently pulverised; the seed too deeply harrowed in, or perhaps too little seed sown. It is common to sow only ryegrass and clover, but where a little extra expense would not be grudged, it is far better to sow a greater variety of kinds, as we thereby make a failure less probable and secure a succession of fresh herbage throughout the year.

The following are the grass seeds often sown in this county, with the cost per acre:—

1 bushel rye-grass	£0	5	6
16 lbs. red clover, at 7*d.*	0	9	4
4 lbs. white clover, at 8*d.*	0	2	8
4 lbs. rib-grass, at 5*d.*	0	1	8
	£0	19	2

And the following is a selection of seeds recommended to me by my friend Mr. Drummond, an eminent seedsman in Stirling. I have used this myself with such marked success that I venture to give the list here:—

Assortment and Proportions of Grass Seeds, recommended by W. Drummond and Sons, for laying down permanent pasture, on medium soil, per acre.

½ bushel Pacey's perennial rye-grass	£0	3	0
½ ,, Italian rye-grass	0	2	9
3 lb. of Timothy	0	1	6
3 lb. of hard fescue	0	1	9
4 lb. of meadow fescue	0	2	4
2 lb. of meadow foxtail	0	2	0
3 lb. of cocksfoot	0	1	6
1 lb. of rough-stalked meadow-grass	0	0	9
1 lb. of wood meadow-grass	0	0	10
1 lb. of evergreen	0	1	3
1 lb. of trefoil	0	0	4
3 lb. of cow-grass	0	2	3
5 lb. of white clover	0	4	2
Price in 1854	£1	4	5

Note.—Perhaps in estimating the price per acre, you should say ranging from 23*s.* to 27*s.* We generally vary the mixture according to the nature of the soil, &c.; and where expense is an object, we would probably keep out a little of the expensive grasses; and where expense is no object, we would recommend the addition of 2 lbs. of alsike clover, and keep out perhaps 1 lb. of each cow-grass and white.

In the breaking up of old grass lands, paring and burning the surface used to be invariably the first step. This is still occasionally done in this county, though not so much as formerly. It has been more frequently ploughed up without paring; well harrowed after lying, and the weeds gathered and burnt. For the first crop, after ploughing out, oats is preferred by some, and turnips by others. It is not often that grass land is permitted to be ploughed out, and when it is, there is generally an agreement for an equal quantity to be laid away in some other part of the farm.

There is many a discussion goes on amongst the agriculturists of this county on the subject of breaking up the old grass land. A few are to be met with who would keep no permanent grass at all, arguing that, with the present improvements in implements, and with the extent of draining that has been accomplished, it would be found far more profitable to grow a larger extent of green crops, and bring up both horses and cattle by stall or box-feeding, or in the farmyard. The greatest number of our farmers are, however, only prepared to admit the advantage of stall feeding so far as it regards beasts to be fattened off for the butcher; and they wholly deny that it can be conducive to the health of horses, or even of cows kept for milking. There is no question then, but our usual extent of permanent grass will be kept up; and, whilst this is the case, it ought to be our care to bring the pastures into a good condition. Throughout great portions of the county they are not so at present. Nearly all our

efforts in draining have hitherto been expended on the tillage lands, and a large extent of grass land remains in a cold wet condition, producing the very rankest kinds of grass, and frequently choked up with moss. It is the opinion of many experienced agriculturists that great benefit would accrue to the county generally, if this land was drained and broken up, other lands, which may have become tired of cropping, being laid away in lieu thereof. A great deal of this wet grass land is not worth above 9*s.* an acre, and yet much of it is situate in such places as would lead us to expect that it might be made turnip soil, and in a few years be trebled in value.

Live Stock.—Great attention has long been given in this county to the breeding and rearing of all kinds of stock. We are not so famous for our sheep as for our cattle and horses. The cattle, known by the name of the Durham short horns, or Teeswater breed, are famed all over the kingdom. Mr. Colling, a celebrated agriculturist in this county, has the merit of first discovering the peculiar merits of the breed, and he, with others in the county, bestowed great pains in improving the breed and rearing various specimens of it, some of which were the wonder of their day. Mr. Bailey, in his 'View of Durham Agriculture,' gives a great deal of information as to the animals of wonderful size, which were reared in the county from about 1780 to 1810; as to the weights to which they attained, and as to the immense sums of money which were sometimes given for them. It is unnecessary for me to dwell on these points, any further than may be necessary in order to draw a contrast with what is desired and accomplished in the present day. The breeders of cattle in 1780, and for some years afterwards, looked too much to the fattening of animals which should be esteemed curiosities from their enormous size; and those of the present day look more to practical utility and the rearing of animals, which shall be the most profitable stock upon a farm, and supply to the market, at the most remunerative prices, the largest amount of good wholesome beef for our increasing population. We seem to think that we have got that desideratum in the "Teeswater" stock, for that breed is all but universal throughout the county. I have just fallen in with a curious little book, published by John Day in 1807, containing an account of "the late celebrated Durham Ox." Mr. Day was the owner of it; he bought it for 250*l.*, and two months afterwards refused an offer of 2,000*l.*! for his bargain. Its weight, when he first got it, was 27 cwt., and in five years it increased to 34 cwt. Mr. Day in his book gives the following particulars, which he thinks essential in the form and shape of a *perfect ox*—particulars which he thought his own possessed in the highest degree. "Head rather long, and

muzzle fine—eyes bright and prominent—ears long and thin—neck gently arching from the shoulders, and small close to the head—breast broad and projecting before the legs—fore thighs muscular and tapering to the knee—legs clean and fine boned—back broad, straight, and flat—hips wide placed, round, and rather higher than the back—carcase, on the whole nearly round." These characteristics are generally developed distinctly enough in the beautiful animals of this breed, to be met with in the county at the present day; and they have other good qualities of perhaps more substantial consequence. They are moderate eaters, quick feeders, soon come to maturity, and the beef is of first-rate quality. They are also excellent milkers, and, what is of consequence in some places, they are very docile and quiet to go about the onstead. I will not here speak of the plan of fattening them in boxes, which is becoming so general, as I shall have occasion to allude to it in another place.*

There are many horses bred in this county. In the midland districts of it excellent cart or farm-horses are reared, principally of the Cleveland breed. Further south, along the banks of the Tees, at Gainford and other places, they breed a number of blood horses, which often bring high prices for the saddle. Many excellent hunters are reared in that district.

The sheep kept on the richer pastures in South Durham are generally the Leicester; on the higher and poor districts the black-faced; in the northern parts of the county the Cheviot; and in many places the farmers prefer a cross between the Cheviot ewe and the Leicester tup, which has become very plentiful. There is also a cross between the Cheviot and the black-faced: indeed, an extensive cattle-dealer, who visits all parts of the county, informs me that there are few sheep in the county of any pure breed, but that he buys crosses of all the breeds in existence. Some of these are greatly preferred to the pure breeds. Pigs are bred and fattened in this county in great numbers, not only by the farmers, but in all the colliery districts every pitman feeds his pig, and throughout the county generally there are few families who have not one or more. It is not possible, or perhaps necessary, to specify the breeds, as there are so many, and it may be sufficient to add that every kind is tried, according to the fancy of the party, and all due pains is taken to promote their fattening; it is a point on which great emulation often exists in a country village, who shall kill the heaviest pig. The general weight is from 20 to 30 stone, but they occasionally reach much greater weights.

* This part of the report has been omitted, the plan of box-feeding not being peculiar to the county reported on.

A very great impetus has been given to the breeding of stock in this county, of late years, by the laudable exertions of the Agricultural Associations, which are very numerous throughout the county. The Durham Agricultural Society holds annual meetings, and offers prizes for the best bulls, of different ages, of the short-horned breed; for the best cow in milk or calf; for Leicester sheep, black-faced sheep; horses, the best blood stallion, the best cart and the best Cleveland stallion; for the best mares for breeding, saddle, harness, and draught horses; for the best foals of different ages, &c., &c. There are Societies at Stanhope, Barnardcastle, Darlington, Staindrop, Stockton, and other places, which offer similar premiums.

Farm-Buildings.—In this county too many of the farm-buildings are in a very indifferent state of repair, as well as insufficient in size and unsuitable to the farm in their arrangements. About fifty, or from that to one hundred years ago, under the old system of farming, the buildings were generally as poor as could well be imagined. Since then they have been gradually getting into better condition, and much has been done towards their improvement, though they are still far from being generally in a good state. I have now before me reports upon 47 farms on one estate, with detailed estimates of the cost of repairs and additions required to the buildings, amounting to the sum of 19,896*l.*: more than this was laid out upon them. Besides the want of repair arising from age and neglect, the principal cause of complaint was the insufficiency of the stabling and byers, and their great want of ventilation. On many of the farms stock could not be reared and preserved in that healthy condition which was so requisite, in consequence of being exposed to all the inclemencies of severe weather without proper shelter. The principal improvements which have taken place in the farm-buildings have been on the larger farms; the buildings on most of the small farms still remain in an unsatisfactory condition. Out of 28 onsteads I have lately examined, 21 were reported upon as requiring alteration and repair.

The chief alterations which have been adopted in modern erections, or improvements, have been to procure—

1. Additional accommodation for housing cattle, rendered necessary by the greater number of cattle fed, and by the preference now given by many to stall-feeding over the ordinary mode by pasturing.

2. Superior ventilation and light in stables and byers.

3. The preserving of the stored crops of all kinds from injury; and

4. The keeping of all manure produced on the premises in its full quantity without waste.

I will endeavour to point out how each of these objects has been accomplished.

1. *Accommodation for Housing Cattle.*—On several farms boxes have been erected, all well covered in, and so arranged as to admit of perfect ventilation. A statement has been drawn up respecting erections made on the farm of Barmston in this county, which it may be worth while to repeat:—

"The house accommodation at present is inferior and inadequate. Where so much has been done, it is very important that some economical mode of construction be adopted; and whilst we certainly should desire something of a more permanent character, we subjoin the particulars of an estimate and specification which may be useful to landlords, as exhibiting a cheap method of affording increased accommodation to their tenants. With care this may last a considerable number of years, until a landlord is gradually able to get over his whole estate with buildings of a more permanent and substantial description. The system of stall-feeding is adopted as the most economical in first cost, and believed to be at least equally profitable, as compared with any other in the progress of the stock. Close wooden sheds are proposed to be erected, 15 feet wide inside, with a feeding passage in front, and a cleansing passage behind the cattle. The sheds are to be made of home-sawn wood, and roofed with the same, coated with coal tar. Inside they are to be fitted in the usual manner, with stalls, mangers, doors, &c. The whole may be so erected at a cost of 10*s.* per head, where the timber is got free on the estate. If the value of the timber is added, the cost will be 30*s.* per head. A shed 70 feet long by 15 feet wide inside, affording accommodation for twenty cattle in stalls, 7 feet to each pair, will cost as follows:—

34,000 superficial feet 1-inch deal, at 12*s.* per 1,000	£20	8	0
50 larch posts, at 8*d.*	1	13	4
40 couple sides, at 8*d.*	1	6	8
20 baulks, at 10*d.*	0	16	8
170 feet wall-plate, at 1*d.*	0	14	2
170 feet runners, at ½*d.*	0	7	1
2 barrels coal-tar, at 5*s.*, in Durham	0	10	0
Nails	1	10	0
Workmanship	2	14	1
	£30	0	0"

More permanent erections than the above for the same purpose have already been erected in the county.

2. *Superior Ventilation and Light in Stables and Byers.*—In no part of our farm buildings has there been greater neglect than in this. Many of the stables especially were without any light or ventilation beyond what was given by the single doorway, and were besides both small and ill-contrived. I went through some new stabling in the county a few days ago, and shall give a few brief particulars by way of showing the improvements that are in course of being effected. The first point which struck me on entering them was their "roominess." The width was 14 feet, 9 of which was the length of the stalls, and 5 the passage behind the horses. There were 6 stalls, each 5 feet 6

inches in width: the height was 9 feet 6 inches. The floors of the stalls have a descent of 2 inches in their length, and a channel runs the whole length of the stable, along which the water passes and is conveyed by a pipe to the liquid manure tank. The stalls are separated by a close partition, 6 feet high at the head, and 4 feet 6 inches at the lower end. For ventilation, cast-iron grated bricks are built in the wall at the level of the ground in each stall, and at the head of the stalls the light was admitted by round windows, moving on a pivot in the centre, and therefore easily opened at any moment to increase the ventilation. They were so placed that one served for two stalls. The mangers, racks, and other fittings, were all of cast iron. There was no loft above, but a coved ceiling, in which were several passages communicating with cupolas of wood, with sides of lattice-work, placed in the roof, by which the heated air passed off. Another mode of ventilation, which has been adopted with great success, is the introduction of 4-inch pipe tiles close to the ceiling above each stall. This is a cheap and simple method, and is said to answer perfectly the purpose, of causing a current of air without any draught which might be injurious to the horses.

3. *The preserving of the Stored Crops.*—To effect this there have been new and improved barns and granaries for the grain crops, and in some places sheds have been introduced to shelter the hay. Turnips and potatoes are generally preserved in pits.

4. *The keeping of all Manure without waste.*—Under this head I may notice the tanks which have been constructed for the preservation of the liquid manure which used (and yet is in many places) to be all lost until a very recent period. These tanks are becoming general, and are differently formed according to the means or fancy of the landlord. The liquid is generally laid upon the grass land, and has been found very beneficial to the fog when put on just after mowing. A plan has been introduced in some places of laying up the manure under cover; and generally throughout the country I see a greater disposition to preserve the farmyard manure from the injurious effects of wind and weather until it be laid into the land. I may remark here, in regard to the use of manures, that a greater degree of care is observed, not only in the preservation of the dung in a good state, but also in regulating the nature and quantity of the manure to the quality or character of the soils. For this purpose bones in all their different forms of preparation, guano, and the various kinds of artificial manures, are very freely used: the latter generally with the turnip crop, though they are sometimes sown over the land and harrowed in with other crops. For the growth of potatoes dung is still preferred; it is, however, well

mixed with ashes, where these can be procured. Lime is in very general use, and is procured in most parts of the county easily and of good quality. Lime, as far as I can learn, was found of universal and inestimable benefit in all the cases of improving common lands to which I have alluded; and, indeed, in the breaking up of old grass generally, it is almost always applied: of course it does not produce the same benefit on land which has not been drained, for it is soon washed through the soil, and, if not taken away entirely, is deposited in a layer between the soil and the subsoil. I once heard of a curious instance where a farmer, accustomed to go through his ordinary routine without much inquiry as to modern improvement, or much study as to the (to him) very "book-learned" doctrines of *cause and effect,* who wondered very much that all the lime he laid on never seemed to be increasing his crops in a similar way as those of his neighbours. He was used to plough the usual regular depth which his grandfather had ploughed, and he never went below; consequently, in the course of years, the plough had worn itself a pretty hard road on the top of the subsoil at the poor man's regulated depth. At length the mystery was cleared up, for one year, venturing a little deeper than usual, he turned up a thick layer of lime almost in the condition in which he laid it on.

Fences and Size of Inclosures.—There is great room for improvement in both these particulars. The fences are generally growing ones, made of the thorn. In the western, or higher district, stone walls are used. In some parts of the county they are in good condition, but in others very bad. A great evil in those parts of the county which have been the longest inclosed and cultivated is, the smallness of the inclosures (from two to six acres) and the breadth of the fences. By both means not only much ground is wasted, but the drying effects of sun and air are kept from the ground, and consequently the ripening of the crops retarded. An antiquarian, referring to our past history, would easily explain both the smallness of the inclosures and the peculiar way in which we see the smallest of them gathered round the various villages. Formerly the whole county was in one vast uninclosed moor, excepting round about the towns or villages, each of which had an extent of ground round it, which was called the "Town-field," or "Stinted Pasture," or "In-Fell." The inhabitants did not do much in cultivating either grain or green crops beyond what the stern necessities of nature would enforce, therefore each individual inclosed his *little patch* of tillage ground as near to his door as he could get it; and in addition to this tillage garth he had one or more "*ox gangs*" or "stints" upon the pasture; and an unlimited range upon the

"Out Fell" was open to him if he possessed an adventurous spirit; but the "Out Fell" was the "unsettled territory" in those days, into which few would venture their cattle for fear of the "inroads of the Scots."

Implements.—There is not much to notice in regard to the implements in use in this county, because, so far as I know, we have nothing but what is already well known, from being in common use throughout the kingdom. I may say, however, that under this head also considerable improvements are taking place in the county. The implements, which at one time used to be of the plainest and roughest class, are beginning to assume a different character, and those of modern invention or improvement are getting into use. The ordinary swing ploughs are in use, and seldom those with wheels. The ordinary rollers, made of wood and stone, are made heavy and invariably drawn by a pair of horses. Crosskill's clod-crusher is used and much approved. If it could be manufactured at a smaller price than 16*l.* to 20*l.* it would be a great benefit to the small farmers of this county. The ordinary teethed-harrows are used, and the improved grubbers and scarifiers have been introduced, though not brought into general use. Turnip and other drills have long been in ordinary use. There are few farms in the county remaining without a threshing-machine: the most of them are worked by horses, but in a few cases steam-power has been introduced. The carts are generally of light and improved construction. We do not see one of the heavy waggons here which are in use in more southern counties. The small implements are just as in other places, and it would not be necessary to refer more particularly to implements, machines, or utensils of the most modern invention, such as chaff cutters, turnip sheers, linseed and chaff steamers, weighing machines, &c. &c., which have not come into common use, but which have all been introduced into the county by a few of our improving farmers.

Charges upon the Farms: Tithes.—I cannot give any correct idea of the tithes without more research than I can spare time for, and more space than it would be desirable to give in this report, they vary so much throughout the county. In some parishes or townships all kinds of tithe had been paid; in others, corn-tithe; in others, no corn-tithe but hay; in some, moduses; in others, small tithes only; so that there was no sort of regularity throughout the county. The operations of the Tithe Commutation Act were carried out in 297 townships or districts within the county, and generally with great satisfaction. The rent-charges were, upon the whole, settled with the best feeling between tithe-owner and land-owner, there being little or no dispute in all cases as to the amount of tithes paid during the seven

years, the average of which was to form the data for fixing the rent-charge.

Summary of Tithes commuted in the County of Durham up to January 1, 1852.

Number of Townships commuted, 297.

Rent-charges payable to			
Clerical appropriators, or their lessees	£11,273	2	2¼
Parochial incumbents	28,070	11	8¼
Lay impropriators	14,118	0	1¼
Schools, colleges, &c.	4,702	1	4¼
Total	£58,163	15	5

Poor Rates.—These are not considered high generally in this county, though the following statement shows a very large increase in the amount raised within the last seventy years. 'The number of parishes in Durham is 310, all comprised in 14 poor law unions:—

Total Amount raised in the County for the Relief of the Poor.

1776	£19,880	17	2
Average of 1783, 1784, and 1785	22,063	5	2
1803	67,517	16	9
1846	94,006	0	0
1851	94,793	16	0
1852	106,847	19	0

Highway Rates.—The highway assessment in this county is generally for a sum exceeding 24,000*l.* The rates vary so much in the different townships that I cannot pretend to give them. In 1850 there was 22,577*l.* raised in money, and 1,949*l.* in team work and other labour performed in lieu of rates. The income of the turnpike trusts in Durham, which is raised by tolls, a large proportion of which is paid by the farmers, amounted in 1847 to 26,716*l.*; and in 1850, to 21,985*l.*—a falling off caused no doubt by the increased traffic on the railways.

Prices of Labour and Piece-work in this County.

A hind's wages—12*s.* and 13*s.* a-week, with cottage found, and sometimes a garden or potato ground.

A labourer	2*s.* and 2*s.* 6*d.*	per day.
Women working in the field	10*d.*	,,
Children	4*d.* and 6*d.*	,,
A ploughing	7*s.* 0*d.*	per acre.
A double-horse harrowing	2*s.* 6*d.*	,,
Cleaning and spreading dung	3*s.* 6*d.*	,,
Rolling	1*s.* 0*d.*	,,
Sowing seed	1*s.* 0*d.*	,,
Stoning and brushing grass	1*s.* 6*d.*	,,
Cutting clover	3*s.* 6*d.*	,,
Manure	2*s.* 6*d.* to 3*s.* 6*d.*	per load.
Shearing and binding wheat	10*s.* 0*d.*	per acre.
A single-horse cart	4*s.* 6*d.* to 5*s.* 0*d.*	per day.
A double ditto	6*s.* 0*d.* to 8*s.* 0*d.*	,,

Draining.—I have already mentioned incidentally, whilst considering other things, that there was a sad want of draining in this county. It must not be supposed, however, that no efforts have been made to alleviate this evil; on the contrary, a great deal has been done, but the misfortune was so much was required to be done that it will be some time before our efforts will take effect upon the general character of the county. There is something in the peculiar formation of the strata of this county which seems to have a tendency to make it more wet than others. Mr. Granger, an eminent agriculturist in his day, published a report on Durham some years before Mr. Bailey's, and in his report he has a map of the county coloured according to the stratification, and I see he calls the strata of almost the whole county "*water-shaken*," doubtless from the peculiarly broken up nature of it, and from its being filled with water. Where the coal has been wrought near to the surface, and the water coming into the colliery through the fissures in the strata has been pumped up and conveyed away, then the district around is no worse than others; but if the coal has not been wrought or having been wrought if the colliery has ceased, and the old workings are filled up with water which has no sufficient outlet, then, in either case, the water must find its way to the surface. There is a great variety of modes of draining practised in Durham: the tiles and pipes are generally used, but they are laid at almost all depths and distances apart. A very experienced man who has been a drainer upwards of thirty years recommends 30 inches deep and 18 feet apart, with 36 inches deep for the main drains. These dimensions are, perhaps, most in use in this county. On the estates of Lord Durham 14,000*l.* have been expended in drainage by the landlord, for which the tenants are charged at the rate of 5 per cent.; besides which, the tenants themselves have occasionally done something. A farmer, who occupies land belonging to his lordship, stated not long ago in a public meeting, that he had drained land himself at an expense of from 10*l.* to 11*l.* per acre. Another tenant stated at the same meeting that for some years he laid out from 100*l.* to 150*l.* a-year in draining, Lord Durham finding only the tiles; he thought, however, that *two crops* paid him back all his money. On the estates of the late Sir Thomas John Clavering, also, a large amount of draining has been executed. Within a short time above 1000*l.* were expended: he also charged the tenants 5 per cent. On the estates of most of the other large land-owners large sums have been expended, but on none of them, perhaps, has there been a more liberal expenditure in draining and improvements generally than on the estates of John Bowes, Esq.; and I think it only an act of justice to make known his liberality, both as an example to

others, and as a refutation, at once complete and undeniable, to the often repeated calumny, that "there is little done in Durham for the improvement of the land." Mr. Bowes possesses three large estates in this county, and I am enabled to present the following particulars of his outlay in improving them:—

STREATLAM ESTATE, in South Durham, the property of John Bowes, Esq.—Amount expended in the Improvement of this Estate from 1841 to 1853 inclusive.

Year.		Expended on Buildings.		Expended in Draining.
1841	....	£279 3 6	....	£230 8 1
1842	....	518 18 6	....	234 13 4
1843	....	1226 19 8	....	707 14 4
1844	....	1504 18 3	....	810 19 7
1845	....	284 2 9	....	544 17 0
1846	....	290 14 5	....	250 6 8
1847	....	1326 6 3	....	583 0 5
1848	....	1349 5 0	....	133 18 9
1849	....	1196 16 0	....	1 3 8
1850	....	1160 17 7	....	53 18 0
1851	....	823 4 4	....	389 4 3
1852	....	856 4 9	....	813 5 9
1853	....	1256 5 8	....	1444 14 4
		£12,073 16 3		£6,198 2 0
Amount of Government grant also expended in addition to the above, in draining on the Streatlam estates during the five years previous to February, 1853				5,000 0 0
				£11,198 2 0

GIBSIDE ESTATE, in North Durham, the property of John Bowes, Esq.—Amount expended in Improvements on the Farm Buildings, &c., from 1842 to 1853 inclusive.

Year.		Amount Expended.
1842	.. ..	£607 3 11¼
1843	.. ..	1266 12 9¼
1844	.. ..	582 19 1
1845	.. ..	251 13 9
1846	.. ..	411 14 8
1847	.. ..	156 16 2¼
1848	.. ..	1131 7 3
1849	.. ..	440 16 6
1850	.. ..	1586 14 7
1851	.. ..	484 2 3
1852	.. ..	551 2 4
1853	.. ..	245 3 11
		£7716 7 8¼

HYLTON ESTATE, in North Durham, the property of John Bowes, Esq.—Amount expended in the Improvement of this Estate from 1842 to 1853 inclusive.

Year.		Expended on Buildings.		Expended in Draining.
1842	....	£101 7 7	....	£345 4 6
1843	....	206 2 1	....	745 16 9¼
1844	....	182 17 8	....	735 16 2½
1845	....	295 1 11	....	767 9 0
1846	....	162 7 7	....	940 14 2
1847	....	216 3 10	....	956 14 4
1848	....	100 9 3	....	1068 7 7
1849	....	861 4 1	....	1016 15 11
1850	....	514 9 1	....	810 15 8
1851	....	292 13 10	....	701 13 9
1852	....	106 0 11	....	566 1 3
1853	....	137 9 11	....	121 13 8
		£3176 7 9		£8777 2 9

Total Amount expended by Mr. Bowes on the Improvement of his Durham Estates.

Streatlam Estates ..	Buildings	.. ..	£12,073 16 3
	Draining	.. ..	11,198 2 0
Gibside Estate	Buildings	.. ..	7,716 7 3¾
Hylton Estate	Buildings	.. ..	3,176 7 9
	Draining	.. ..	8,777 2 9
	Total	.. ..	£42,941 16 0¾

At Streatlam, during the first five years, the drains were cut from 2 to 3 feet deep and from 6 to 9 yards apart. The remainder was put in 4 feet deep and from 36 to 40 feet apart. The tenants lead the materials and pay 7 per cent. on the landlord's outlay. No interest is charged on the large amount expended on the improvement of the buildings. The farms here are generally let from year to year. This estate many years ago had, from various causes, got into a very bad condition during the lifetime of the late Earl of Strathmore, and the trustees, during Mr. Bowes's minority, laid out from 20,000*l.* to 30,000*l.* upon the estate, previous to and altogether irrespective of the above liberal outlay by Mr. Bowes himself. Upon the Gibside estate the draining has just been commenced under the "Private Money Drainage Act." Not another word need be added to set forth the laudable attention of this gentleman to the improvement of that portion of the county of Durham which belongs to him.

The expense of draining is so very uncertain—altogether depending upon local circumstances, that it is impossible to give an accurate account of it. It may, however, be useful to give some ideas respecting it by the following exact account of the expense of draining a field containing 11A. 1R. 20P. executed in this county not long ago.

The Actual Cost of Draining a Field in the County of Durham, containing 11 acres, 1 rood, 20 poles.

	£	s.	d.
Drain along top, 59 roods, 4 feet deep, at 1*s.* 3*d.* ..	£3	13	9
Tile drains—			
24 roods of main drains, 3 feet deep, at 1*s.* ..	1	4	0
406 roods of furrow drains, 32 inches deep, at 7*d.*	13	6	0
50 do. do. 30 inches deep, at 6*d.*	1	5	0
Stone drains—			
30 roods of main drains, 3 feet deep, at 8*d.* and 9*d.*	1	1	7
Cost of pipe tiles—			
10,660 pipes, at 16*s.* per 1000	8	11	0
590 No. 3 tiles, at 3*s.* 6*d.* per 100	1	0	7
420 No. 2 tiles, at 2*s.* 6*d.* per 100	0	10	6
7 yards of socketed water pipes, at 3*d.* per yard	0	1	9
Labour—			
Leading materials	6	11	4
	£37	5	6

Before leaving the subject of draining I would beg to direct attention to a point which has, I fear, been partially neglected in draining particular districts of country—I mean the condition of the main or trunk drain. I do not refer to the main drains laid in a farm or in a range of fields, but to the stream or river which forms the main drain of an entire district. I would point out the evil I allude to by reference to a case in this county which I have in view. Down the middle of a valley, with a large extent of sloping country rising up on each side, runs a stream, which is the main or trunk drain for many hundred acres of land lying on either hand of it. On each side of the stream there is a good breadth of haugh land, which stretches across, pretty level, from the foot of one sloping ground to the foot of the other. All the drains of the district must necessarily have their final outlet in this stream, which in turn has *its* outlet in a river up which the tide flows. The velocity of this valley stream is very trifling, with occasionally places of almost dead level, for two miles or more previous to its reaching its outlet. Thence arises the practical evil. The tide flowing up the river meets every wet season a flood of water rolling sluggishly down this stream and dams up its outlet. The flood thus pent up spreads over the haugh lands, and for many days together they present the appearance of a lake—very beautiful to the eye, but most disheartening to the farmer, for his lands are half covered, his drains are all stopped, and they are often permanently disordered, filled up with sediment and stopped. A remedy, or at least an alleviation of the evil is very apparent. The stream twists through the haughs like the writhings of a serpent. Cut off some of the folds and you might shorten its length by one-half, and thus in-

crease the velocity of the current and carry the floods quicker away.

General and concluding remarks.—What remains to be said is a summing up of the substance of my Report, including a statement of the changes which have taken place since 1810, the date of Mr. Bailey's Report, and of the further changes or improvements which seem to be required.

I will attempt to do this very briefly. A considerable prejudice exists against *Durham* farming; it has been styled the worst in the kingdom, and the landlords have been accused of doing little or nothing for their estates. I admit that the average state of the farms in this county is behind the condition of farms in other counties; but I have broken down the force of the charge—1st, by alleging five good and substantial reasons why we should have expected it to be so, or, as I before expressed it, five *obstacles to the improvement of agriculture in this county;* and 2ndly, by proving (which, I think, I have done very completely) that a great deal has been done in the shape of improvement; and, therefore, that the charge of bad farming is rather more applicable to our predecessors in the county, during a generation or two ago, than to ourselves, inasmuch as we have made great efforts, and are already treading upon the heels of more advanced agriculturists.

The changes, in the shape of improvement, since Mr. Bailey's time, I think to be these:—

1. A large extent of common lands divided, and a large portion of them brought into a state of cultivation, and rendered of very much increased value.

2. A large amount of draining effected throughout the county, by which the average produce of all crops has been increased, and turnips and other green crops are now grown where our forefathers never grew them.

3. A great improvement in the state of the farm-buildings; and

4. An improved course of cropping arising out of the draining, which prepared the way for the introduction of green crops, and made it possible to do away with the objectionable practice of taking two corn crops in succession.

The improvements which we should earnestly seek in future years may be said to be principally these:—

1. The enfranchisement of all the Church leasehold property. I have received several letters asking me to urge this on the attention of all concerned; and, since writing the earlier portion of this Report, I have had a long conversation on the subject

with a gentleman who farms in the neighbourhood of Gateshead; he tells me that his farm averages 3*l.* 15*s.* an acre, the taxes amounting to another 1*l.*; and that another farm adjoining to his being to let, he was asked to take it, and offered 2*l.* an acre, on condition that it should be drained. "No," replied the agent immediately, "Mr. —— *never will drain those leasehold lands.*" Here was at once a proof of the injury done to agriculture in Durham by the existence of this property, in which nobody feels possessed of any permanent interest.

The lessee has no encouragement to improve; for, though he possessed a lease, he knew that upon his expending money on the property he would (upon the next renewal) have to pay over again for his own improvements in the shape of an increased fine, fixed from the annual value of the property *after the improvements are added.*

In the case just alluded to, the lands being near to a large and rapidly-increasing town, could, on being drained, have been easily raised to the value of 4*l.* per acre, and now they cannot be let for 2*l.* Surely no further proof is required of the great advantage likely to accrue from the enfranchisement of this property.

2. The extension of the draining operations, so as to include not only the tillage lands, but all those held with them, which are in permanent grass.

3. The improvement of the permanent meadows and pastures *after draining* by ploughing out large portions now badly laid away, taking care that a sufficient quantity is laid down in lieu thereof.

4. The extension of the plan of Stall-feeding Cattle.—By this method a great deal more stock can be fed on the farms than by pasturing. There is a quicker turning over of the farmer's capital. By an increased stock, and by the purchase of linseed, oil-cake, and other food not produced on the farm, the quantity of manure as well as its quality, is greatly increased; and consequently, the farmer is able to bring his lands into a richer state.

All that is necessary to accomplish the general adoption of this plan is the *draining*, by which turnips will be produced; and a little addition to the farm-buildings. From all the information I have received I have not the shadow of a doubt of its being profitable to the tenant, and therefore of advantage to the landlord too.

5. The planting of a large quantity of land in various districts.—I should, according to proper order, have referred to this before: I left it until now, because I had much to say upon it, but it should follow, and I have no doubt *would* follow, imme-

diately after the enfranchisement of the leasehold lands. Even on the freehold lands there might be much planted with advantage. I have taken some pains to watch the effects of planting in other counties, and have for many years been of opinion that it was a great oversight of the landowners in Durham to leave so much of the county in that naked and bare condition in which it has so long stood. I believe one reason why more has not been planted is, that gentlemen who have planted have thought it an expensive and unprofitable undertaking. But there has been, I conceive, a grand mistake committed in most of the planting which has been undertaken. A proprietor, resolving on making some plantations, sets out some long narrow belts, requiring, it may be, some miles of fencing, the very expense of which is enough to sink the undertaking at once, and having put in his trees, there he leaves them to the care of Nature and the weather. A different system should be adopted. We should set out with two leading principles in our mind, or, as I might say, with two important objects to be accomplished; 1st. That if extensive woods were reared in certain places, they would not only use up a quantity of land which does not now pay for cultivation; but they would, by the shelter they afforded, raise the value of the adjoining lands (as some think) 20 per cent. I have no doubt that, if done in connection with the draining and other improvements previously referred to, we might say, in certain localities, from 30 to 40 per cent. 2nd. That, if properly attended to, a crop of timber is just as profitable as all the crops of grain or green food which might have been produced upon the land during all the years that the wood would stand. This may be thought, perhaps, a strong assertion, but I think facts and experience will fully bear it out; and the reason it has not been made more manifestly apparent is just the fact already referred to, viz.: the trees are not looked after as a crop worth cultivating, but are just left, in too many instances, after being planted, to care for themselves. It is the fashion in the county of Durham, when talking on this subject, to refer to Chopwell woods, situate within the county, as a standing example or warning against planting. I may, therefore, be allowed to refer to them, and indeed the great importance of the subject now under consideration will fully justify a little more space before concluding my Report. The Chopwell woods, situate in the Vale of Derwent, are the property of the Crown, and contain 896 acres. They have been for years notoriously under a neglected management. The trees are oak, ash, elm, sycamore, beech, birch, and alder. The land is a strong stiff clay with mixture of sand veins, and is full of water. These woods were in so bad a state that, on an examination made a few years ago, 779 acres were recommended to be wholly

cleared, in order that *the land might be properly drained.* The net revenue derived from these woods was:—

	£.	s.	d.
In 1849	75	2	8
1850	105	4	11
1851	237	15	9
1852	300	15	0
1853	687	7	0

So far, then, from the state of Chopwell Woods being any good argument against the recommendation I desire to make, it gives us, I think, an argument of a contrary tendency; for the facts it fully bears out are: 1. That want of draining and neglect of the trees has been the sole cause of ill success; and 2. That even with that great disadvantage the revenue is a progressively increasing one.

In order to point out the advantage of that system of planting which I recommend, I may refer to another locality in the county, where the plan is being tried. In Quarrington, Coxhoe, Thrislington, and the neighbouring district, there is a large proportion of lands worth to rent 2*s.* 6*d.* an acre. They are moderately dry and would not require so much draining as land in some other parts. An acre would be sufficiently drained for plantations by open drains at something like the following cost:—

	£.	s.	d.
380 yards, open drains, at 1*d.* a yard	1	11	8
35 yards, main drains, at 2*d.* a yard	0	5	10
	1	17	6

At Thrislington about 100 acres were planted with larch several years ago, the expense of planting, including trees, being 50*s.* per acre. When the trees came to 12 years growth Scotch kyloes were pastured amongst them: they were found to do no harm to the trees, and I am told it is remarkable how well they fattened, the pasturage was so good. I cannot say, however, that I would recommend cattle being put in so early as 12 years; at 15 or 20 years more trees will have been thinned out, and during the last 20 years of the term of 40, during which the larch will stand, the pasturage will be easily available, and undoubtedly of value. At Thrislington the larch were planted after clover, so that the ground was in better state than after any grain crop. One ordinary ploughing was all the work bestowed on the land previous to planting the trees. Larch has been strongly recommended by many competent judges as that species of tree which will thrive best and grow the quickest in the soil and climate of our county. There is also a great and increasing demand for larch timber in the colliery districts.

Let me now conclude by giving a comparative financial statement, which, I think, will very strongly enforce the recommendation, that large quantities of land in this county should be planted.

Prospective Valuation of the Amount to be realized by planting 100 Acres of Land with Larch.

Planted 1854, with 2,700 trees per acre, or in all 270,000.

	£.	s.	d.
In 1864 thin out 500 per acre, sold at a net profit of 1*d.* each	208	6	0
In 1869 thin out 500 per acre, at a net profit of 2*d.* each	416	12	0
In 1874 thin out 500 per acre, at a net profit of 4*d.* each	833	4	0
In 1879 thin out 500 per acre, at a net profit of 8*d.* each	1,666	8	0
In 1890 thin out 250 per acre, at a net profit of 4*s.* each	5,000	0	0
In 1892 thin out 250 per acre, at a net profit of 5*s.* each	6,250	0	0
In 1894 there would be 20,000 trees left standing well worth, on an average, deducting expenses, of 10*s.* each	10,000	0	0
	£24,374	10	0

Deduct—

	£.	s.	d.	£.	s.	d.
Loss of agricultural rent, 100 acres at 3*s.* per acre, for 40 years	600	0	0			
Expense of draining and planting 100 acres, at, say 5*l.* per acre	500	0	0			
Woodkeeper's wages, 2080 weeks at 14*s.*	1456	0	0			
Expenses of selling wood	118	10	0			
				2,674	10	0
Extra profit derived from the 100 acres				£21,700	0	0

If my estimate be correct, the proprietor, or his heir, at the end of 40 years, will be in possession of no less than 21,700*l.* more than he would have been under the old system; and in addition, after the roots are stubbed up, and the lands receive a moderate degree of good treatment in the shape of manure, he will have his 100 acres of land in a *better condition* for agricultural purposes than it was when he commenced.*

I have now completed my task; whether it shall be successful or not I cannot tell; but this much I may be allowed to state,

* With reference to the above estimate, it must be remembered that, on very poor land, out of 2700 trees per acre, a large number would never grow to have any pecuniary value. I am informed by an experienced planter, that in the South of England trees must grow very well for 500 to be taken out in the first 20 years worth on the average 3*d.* each, unless the best were taken out; and that where carriage is expensive, poles of 40 years' growth do not often fetch more than from 2*s.* to 3*s.* 6*d.* each. Proximity to railways, to the sea-coast, or to coal-pits, may perhaps raise the price in Durham, but it must be remembered that the land here spoken of is assumed to be worth no more than 3*s.* per acre.—T. D. Acland.

with all respect for the Royal Agricultural Society, that I have been as much induced to undertake it, by a desire to set the agriculturists of the county of Durham in a right position before their brother farmers throughout the kingdom, as by any wish to obtain the prize, however great may be the honour of doing so. Gratitude and friendship weigh much with me. My family *for many generations* have been connected with the agriculture of Durham and Northumberland. All that we have had, and all that we now possess of earthly goods, we owe to it—to the kind patronage of the landowners, and the good-feeling and hearty co-operation of the tenants. Take them all together, there does not exist a more honourable and liberal body of proprietors, or a more honest and industrious body of tenantry than prevails in those two counties, and I should not be worthy of the ability to take up a pen, if I did not feel it at once a pleasure and a duty to use it in favour of these, my best friends, so far as the sacred requirements of truth would allow me.

V.—*On the Composition of the Waters of Land-Drainage and of Rain.* By J. THOMAS WAY, Consulting Chemist to the Society.

I HAVE for some time past been anxious to institute an examination of the waters of land-drainage with the view of ascertaining whether the advantages derived were attended by an incidental loss of manuring matter carried off in the drains, and if so, to what extent this loss might occur. Such an examination would seem to follow naturally the inquiries in which I have been heretofore engaged, in respect to the absorptive properties of soils for manure. It is the object of this paper to communicate such results as have up to this time been obtained. As however an inquiry of this kind involves much time and labour, the results now given must be considered as an instalment only, and considerable caution will be needed in their application. I propose to point out the general bearing which they have; but it must be left to future inquiry to settle questions of detail.

The valuable effects of land-drainage are well known, and have been repeatedly explained; they are partly physical, partly chemical. The chemical effects, with which alone we have now to occupy ourselves, are consequent chiefly upon the free admission of air which follows the removal of water previously filling the interstices of the soil. This air, by virtue of the oxygen it contains, gives rise to the decomposition of organic matter, such as the decaying roots of plants, &c., or that which

in the shape of manure has been added to the soil; the carbonic acid so formed, assisted by that which naturally exists in the air, gradually breaks down and decomposes the minerals of which the soil is composed, rendering them soluble and available for vegetation. In a similar way, of course, it affects such mineral substances as may be added in manure. In this manner, therefore, drainage produces a more abundant supply of different substances necessary for the growth of plants. But as the water which passes through soils in its way to the drains would carry away with it everything which, under such circumstances, it was capable of dissolving, and as in the absence of any cause operating to prevent it, this water would also remove all the soluble matters of manure, it becomes of great importance to ascertain whether there really are any preservative causes at work to counteract so very serious a mischief.

This question has been, to a great extent, answered in the affirmative, by the discovery of the absorptive property of soils, which enables them to convert into comparatively insoluble compounds all, or nearly all, those salts which are valuable as manure. From these experiments we should predicate that drainage-water would contain a certain portion of all those substances which are necessary to vegetation, because some degree of solubility is indispensable to everything which is to form the food of plants; but we should not expect to find them in such quantity as would be the case were there no provision for their retention by the soil itself.

We shall presently see how far these anticipations are borne out by the result. To obtain a clear notion of the effect of drainage upon the soluble matters of the soil we shall do well to consider separately the following points:—

First, The quantity of rain that falls, and how much of that quantity finds its way into the drains.

Second, The composition of this water.

Third, Where the substances (if any) contained in drainage-water are derived from; and,

Fourth, What circumstances are likely to increase or diminish the waste from such cause.

1st. *The quantity of rain falling and percolating through soils.*—The rain-fall, as every one knows, varies very much in different places. As regards Great Britain, the quantity of rain falling in the west considerably exceeds that which has been observed in the east and centre. Thus I find the following stated as the average annual fall of rain, in inches, in some of the western counties, from north to south, of the kingdom:— *

* Morton's 'Cyclopædia of Agriculture,' article 'Climate,' page 475. I have omitted fractions in the quotations above.

Cornwall, 38; Gloucester, 30; Lancashire, 34; Bute, 38½; Orkney, 41. These numbers would give us for the West of England, taken collectively, an average of something more than 36½ inches per annum as the rain-fall.

On the other hand the quantity falling in the eastern and midland counties is thus given:—Suffolk 23¼, Middlesex 25, Nottingham 25, Fife 31, Perth 24—giving an average for these counties of 25½ inches. But besides these general distinctions which apply more or less to the whole of the two opposite sides of this island, there are local variations of every imaginable character due to height above the sea, the neighbourhood of hills, or to the form which currents of air assume at different places, &c. &c. It is notorious to every one that the quantity of rain which falls, and the way in which it is distributed—whether in large quantity at distant intervals, or in continually recurring showers—are different in almost every different locality. The period of the year has also an influence on the quantity of rain that falls; it is generally greatest in the autumn and least in the spring. But although, no doubt, all these circumstances would have to be taken into account, if we were attempting a very accurate estimate of the result of drainage, they need hardly trouble us here, since some general and wide deductions are all that we are at liberty to form from the data at our disposal. I shall assume for the sake of argument a rain-fall of 25 inches, both because it is a convenient number and because it fairly represents the quantity observed in the districts from which my principal samples of drainage-water were collected.

By calculation we find that 25 inches of rain over an acre of land is equal to 567,168 gallons, or about 2532 tons a year—a quantity which is enormous, but which must be increased by nearly one-half for the western counties and to a still greater extent for Ireland.

Let us now see what proportion of this amount finds its way into the drains under ordinary circumstances. There have been, no doubt, direct observations of the quantity of water running in the drains of a given area of land, and I have found some of these mentioned in different books. If you could do it, there is no question that the surest way of getting at this result would be to gauge the drainage-water escaping from a certain number of acres of land at the same time that you ascertained by the ordinary rain-gauge the quantity of rain falling. But such a method seems open to much doubt from the uncertainty as to whether in some cases part of the water may not escape by other means than the drains, or, on the other hand, its quantity be increased by soakage from external sources. It appears to me that the best mode of forming an estimate on this subject, is that

which was adopted by Mr. Parkes,* founded on the observations of Mr. Dickinson, the eminent paper-maker. That gentleman had for many years kept registers of the ordinary and Dalton rain-gauge. The object of the last named instrument is to ascertain the quantity of rain which penetrates the soil to a given depth. Now it must be remembered that although all the rain that falls must necessarily be disposed of somewhere, there is another influence besides filtration at work, and that is evaporation. In the hot seasons of the year a great deal of water is thus thrown back into the air, and this is especially the case where, as in ordinary agriculture, the land is covered with plants, which taking up the moisture of the soil by their roots, exhale it by their leaves, and thus most materially increase the ordinary evaporation from the soil.†

The Dalton rain-gauge consists of a metallic vessel of about 3 feet deep, sunk into the ground, level with the surrounding earth, but furnished with a rim to prevent the passage into it of any water except that which absolutely falls upon its surface. It is made—like other rain-gauges—of a given superficial area, but the chief peculiarity in it is, that it is filled with earth, so as to represent the soil with which it is desired to compare the results. In the case now alluded to, the soil in the gauge was covered during the whole period with grass.

An arrangement is made by which the water which penetrates to the bottom of the earth—a distance of 3 feet—is measured at stated periods, as in the ordinary gauge. Now as evaporation from the surface will dispose of some portion of the water which falls in rain, it is obvious that the quantity which penetrates to the bottom of the Dalton gauge would be less than that collected in an ordinary gauge. In fact the results of this gauge are the measure of the quantity which, in a similar soil drained to the same depth, would be disposed of by the drains. We have but to compare the indications of the two gauges for any given period, to know at once how much of the rain-fall is thrown into the air by evaporation, and how much runs off by the drains. The use made by Mr. Dickinson of this register was in no way connected with agriculture, but the results are precisely such as we should desire to possess in dealing with the question in hand.

In a Table, which I here take the liberty to reprint, Mr. Parkes gives the quantity of rain and percolation in each year of a series of 8 years, as ascertained in Mr. Dickinson's gauges. In the 5th column the quantities are given in tons per acre :—

* See his 'Essays on the Philosophy and Art of Land Drainage;' Journal of the Royal Agricultural Society of England, Vol. V., Part I.

† Messrs. Lawes and Gilbert, who have made some experiments on this subject, found that the quantity of water thus exhaled from a given space of ground is very large indeed, amounting to more than 100 times the weight of the crop at the time of maturity.

TABLE I.—Rain-fall, Evaporation, and Filtration in each of 8 years (Parkes).

Years.	Rain.	Filtration.	Evaporation.	Rain per Acre.
—	Inches.	Per cent.	Per cent.	Tons.
1836	31·0	56·9	43·1	3139
1837	21·10	32·9	67·1	2137
1838	23·13	37·0	63·0	2342
1839	31·28	47·6	52·4	3168
1840	21·44	38·2	61·8	2171
1841	32·10	44·2	55·8	3251
1842	26·43	44·4	55·6	2676
1843	26·47	36·0	64·0	2680
Mean ..	26·61	42·4	57·6	2695

It will be seen that of the whole water falling in rain, 42·4 per cent., or, in round numbers, 2-5ths passes through to the drains. This number is the average of 8 years, which vary within rather wide limits, being in one case as low as 33, in another as high as 57.

At first sight it does not appear why this should be the case, but a little consideration makes it evident. In heavy rains, and when the soil is already saturated with moisture, all the water which falls, if it does not flow over the surface, will find its way into the drains, there being, at such times, little opportunity for evaporation. When, however, the rains are frequent, and comparatively light, with intervals of warm sunshine, the quantity of water which would suffice to saturate the land is carried off by evaporation before the next shower, and none at all reaches the drains. Thus, as each year has its own peculiar distribution of heat and sunshine, so it will be with regard to percolation.

This is well shown by the following Table, taken from Mr. Parkes's Essay before quoted.

TABLE II.—Mean Rain-fall, Evaporation, and Filtration and Evaporation in each month (8 years).—(Parkes.)

	Rain.	Filtration.	Evaporation.	Filtration.	Evaporation.
	Inches.	Inches.	Inches.	Per cent.	Per cent.
January	1·847	1·307	0·540	70·7	29·3
February	1·971	1·547	0·424	78·4	21·6
March	1·617	1·077	0·540	66·6	33·4
April	1·456	0·306	1·150	21·0	79·0
May	1·856	0·108	1·748	5·8	94·2
June	2·213	0·039	2·174	1·7	98·3
July	2·287	0·042	2·245	1·8	98·2
August	2·427	0·036	2·391	1·4	98·6
September	2·639	0·369	2·270	13·9	86·1
October	2·823	1·400	1·423	49·5	50·5
November	3·837	3·258	0·579	84·9	15·1
December	1·641	1·805	0·164	100·0	00·0
Mean of eight years	26·614	11·294	15·320	42·4	57·6

In the 4th and 5th columns we have the percentage of filtration and evaporation in the different months of the year, and we find that in the three first and three last months in the year, the water which is disposed of by filtration, greatly exceeds that which escapes by evaporation; whilst in the summer months, if we may so call the six intermediate ones, the quantity of drainage-water is reduced to a very low point, and in those of May, June, July, and August, it is practically insignificant. Nor must this be thought foreign to our subject, for, inasmuch as the decompositions which occur in the soil, are, in a great degree, modified by the temperature and the degree of moisture; and as these are concerned in the liberation of elements of vegetation, which might be supposed to be removed by drainage, it is important to bear in mind that the flow of water through a soil is not uniform in the different months of the year, but is in fact very much greater at those seasons when the activity of vegetation and of decomposition in the soil is in great measure suspended.

For our present purposes we shall, therefore, assume that 42·4 per cent. of all the water falling from the heavens filtrates through the soil. It is obvious, that if we know the rain-fall of any locality in inches, it is easy to calculate approximately the number of gallons of water which, in the course of twelve months, will drain from an acre of land. I say approximately, because it has already been seen that it is by the distribution of the rain-fall, rather than the quantity which falls, that the amount of drainage-water is regulated. It is well indeed that we should, once for all, observe, that however elaborately an examination of this question of the composition of drainage-water might be carried out, the results at the very best can only be general. It is practically impossible that any collection of specimens should furnish the data for a rigid determination of the truth. We cannot collect the whole drainage of the year of any considerable portion of land, and as we know from reasoning that its composition must be continually varying, samples taken from time to time, however frequently, cannot by possibility be supposed to represent the whole year.*

* It would be indeed possible, at a considerable expense, to accomplish this object. A given area of surface-soil, lying on an ascertained clay-bottom, might be isolated, by means of a puddled dyke, from the remainder of the field, with which, in other respects, it would altogether accord. A tank, sufficient to hold the drainage of the interval of time elapsing between the collection of the samples, might be constructed in such a way that the quantities might be accurately measured. It is obvious that in this way, by taking from time to time samples for analysis, we might ascertain, with tolerable accuracy, the total quantity of various substances removed from a given area of land within the twelvemonth. The same object might be accomplished, though perhaps less satisfactorily, by means of a large Dalton gauge.

Reverting now to our previous calculations, we find that on the supposition of a rain-fall of 25 inches (which we have found to be equal to 567,168 gallons, or 2532 tons), and further granting that the average annual filtration is equal to 42·4 per cent. of the whole, we shall have a quantity of 240,479 gallons, or about 1073½ tons passing into the drains.

Such being the quantity of water which probably represents the *minimum* running away in any one year by drainage, we have now to consider—

2nd. *The Composition of this water.*—Analyses of drainage waters more or less complete have from time to time no doubt been made by different chemists; hardly, however, it would seem with the objects which we have at present in view.* The only recorded instance which I have been able to find is that of an analysis by Mr. John Wilson, now professor of agriculture in the university of Edinburgh.

In the autumn of last year, through the kindness of Mr. Dyke Acland, Mr. Wren Hoskyns, and Mr. Paine of Farnham, I obtained samples of drainage water from their different localities.† It will no doubt be supposed that in commencing an inquiry of this kind one would naturally make a selection of different soils; of the same soils under different treatment as to manures, &c.; of different depths of drainage and varying climate. My answer is, that to accomplish such an extensive plan as this—although indeed it may ultimately be very desirable—would, not to speak of difficulty and expense, require years rather than months, and that a preliminary inquiry, such as I have now the pleasure of placing before the readers of this Journal, far from tending to mislead, will clear off many of the uncertainties of the question, and leave the points of future research far less numerous and obscure. For the reason that the waters were collected under his own eye, that his agricultural operations are most carefully recorded, and that his land is farmed very highly, and would certainly afford a maximum of effects as referable to drainage, I have employed the time at my disposal to make a more perfect examination of the waters collected by Mr. Paine than of any others; which latter, however, I shall have occasion to recur to at another opportunity.

Before giving the results of these analyses, I would state, for the information of the general reader, that the analysis of samples of

* I have, on several former occasions, examined the waters of land-drainage, with the view of ascertaining whether, in the particular instances, they were fit for domestic use, for which they are frequently employed.

† Several other gentlemen, amongst whom I may mention Mr. Bailey Denton, Mr. Girdwood, and Mr. Scott, were good enough to furnish me with samples, which as yet I have not had time or opportunity to examine.

water is much more difficult than that of minerals or other solid substances, for the reason that whereas in the latter the chemist will probably be able to have at hand any moderate quantity to operate upon, in the former he will probably find not more than 30 or 40 grains of solid ingredients in each gallon of liquid; and as it is upon these ingredients that the examination is really made, there is practically a limit easily reached to the quantity of matter which can be brought under analysis. Now, when it is further considered that the analysis will be made probably upon a gallon of water, and that as nearly a quarter of a million gallons run through the soil in the course of the year, it will be seen how great an error may be introduced into any calculations which are founded on an imperfect analysis.

One grain of any particular substance in a gallon of water will in fact amount on the whole drainage of an acre of land in the year to 240,000 grains, or about 34½ lbs.

Still more does this remark apply to such substances as are, when even in considerable quantity, difficult of precise determination, as nitric acid and ammonia; and to ascertain the quantity of which, in very minute proportion, is almost beyond the present skill of the chemist. When the samples of drainage water reached me I soon found that they contained nitric acid, although sometimes in small quantity only. For the estimation of this substance, in minute proportion, there was absolutely no existing process; and as it was obvious, from the beginning, that a great deal of the interest of the subject would be dependent upon the compounds of nitrogen, which are so very important to vegetation, it became indispensable that some method should be discovered, by which the small quantities of nitric acid in the drainage waters might be accurately determined. To this question I accordingly addressed myself, and in concert with my principal assistant (Mr. E. O. Browne) succeeded, though only after uninterrupted attempts for several months, in devising a process by which very minute quantities of nitric acid can be most accurately ascertained. I have given a full account of this method in an Appendix to the present paper, but I call attention to the subject especially here, because it is well that agriculturists should remember that the applications of a science are bound up intimately with the progress of that science itself; and that often it becomes impossible to make a step in advance, which a superficial observer might think easy enough, simply because that step presupposes a state of knowledge or power in science which does not presently exist. Thus in this case the acquisition of satisfactory knowledge, with respect to the composition of drainage waters for the purpose of agriculture, involved the necessity of a new process of chemical analysis; and whatever the time and

trouble required, nothing short of the accomplishment of this object would have been of any avail.*

I proceed now to give the analyses of samples received from Mr. Paine; they were collected on the 26th and 27th of December in last year (1855) at Farnham in Surrey.

The following is the description of the different samples as given me by Mr. Paine. I place them together in order that the analyses may be grouped as far as possible in Tables, by which a saving of valuable space will be obtained.

Mr. Paine says—

"The drains had been quiet for a very long period, and in most cases you have now the first rinsings of the land.

"The first six specimens were collected on the afternoon of the 26th, when I and the men who were with me got a most thorough soaking. Nos. 7 and 8 were collected on the afternoon of the 27th, and then the drains did not run a tenth part so furiously as they did the day before, and as you will perceive the water was much *clearer*. In the first place I must observe that during the night of the 24th there fell half an inch of rain, but this had not much influence on the running of the drains, as the frost was not out of the ground, and thus the water was kept on the surface. Between the night of the 25th and the afternoon of the 26th, upwards of another half inch of rain fell, at times pouring down in torrents like summer thunder-showers. The ground then became thoroughly saturated with wet, and the drains ran quite full, and the water was very turbid. I give you the names of the fields, that I may recollect the water when I happen to be in your laboratory.

"No. 1.—From the main drain in Piping Lane Field. This field was drained in 1852 when I purchased it. The land was then in the most impoverished condition. After draining it was *trenched* (as indeed is the case in nearly all my land). The subsoil is gault clay, over which lies drift gravel, varying from one to five feet in thickness. In 1852 the field was well manured for swedes with dried blood or guano and superphosphate, having been previously *limed* at the rate of 160 bushels per acre. In 1853 the swedes were fed off by sheep, with oilcake and hay, and gave a good crop of wheat. In 1854 no manure for swedes: in 1854–55 with 4 cwt. of guano for wheat. There has been no manure put on the land since last winter—it is now under the process of fallowing for swedes.

"No. 2.—From a long single drain in Manley Bridge South. This field was also drained in the winter of 1852–53. It was then a wretchedly poor meadow, producing scarcely any herbage. The subsoil is gault clay, but there is a good surface soil 18 inches deep. After draining, it was trenched and planted with hops. In 1853 it was manured with 5 cwt. of guano, and 5 cwt. of superphosphate per acre; in 1854, 15 cwt. of horn shavings and 200

* Since I have been engaged upon this subject, M. Ville of Paris, who is well known for his beautiful experiments upon vegetation, has also discovered a method adapted to the same end. My present process was far advanced towards the perfection which it has now reached before the first notice of M. Ville's method was made in the French scientific periodicals. They are in no way at all alike, and are based upon totally different principles. It serves, however, as another proof of the necessity which existed on the subject, and of the general concurrence which is often observed between different minds, that two chemists should, at much the same time, have, independently and unknown to each other, been engaged successfully in the solution of the same problem.

bushels of lime per acre; 1855, 20 cwt. of rabbit skin waste, and 3 cwt. of guano per acre. The hops in this field grew most luxuriantly.

"No. 3.—From a long single drain in Holt Forest Hop Ground. This enclosure was drained in the winter of 1853–54. It was previously part of the Holt Forest, lying as a poor commonage pasture, from which all the droppings of the cattle were continually picked off. The subsoil is gault clay, with very little surface mould; it was manured in 1854 with 6 cwt. of guano, and 6 cwt. of superphosphate; and in 1855 with 30 cwt. of rags per acre.

"No. 4.—From a main drain in Broad Well at Clay Hill. This field was drained about ten years ago. This soil is a dirty gravel, lying upon gault, and in most places the drains did not penetrate into the clay. The last crop on this field was wheat, having been previously manured with 4 cwt. of guano per acre in the autumn of 1854. Prior to this the field was in a state of *good* cultivation; and has been chiefly manured for some years past with guano or dried blood and superphosphate of lime, and was limed at the rate of 160 bushels per acre four years ago.

"No. 5.—From the main drain in Tanner's Turnpike Field. This was drained and trenched in 1852–53. The subsoil is gault with an overlayer of gravel, from 1 to 8 feet deep. At the above period this field was in very poor condition. It was manured with dried blood and superphosphate for turnips in 1853. The turnips were fed off by sheep, receiving oilcake, &c., and sown with wheat in the spring of 1854. It is now sown with wheat, having been manured with 4 cwt. of guano per acre. The drains in this field have not run till now since this guano was applied.

"No. 6.—From the main drain in Marshall's Hop Ground. This was drained about fourteen years ago. The soil is a rich loam 3 to 8 feet deep, resting upon gravel. It has been under hop cultivation about twenty-five years, and as regards manure, is in the richest possible condition, having received every year either 30 tons of good dung, or 30 cwt. of rags or hair, or some other equivalent. Last year it received 40 tons of dung per acre.

"The following were collected on the 27th December:—

"No. 7.—From a main drain in the Furze Field. This field was drained in 1846. It was then trenched and planted with hops. Since that period it has been abundantly manured every year. The manure in 1855 was 15 cwt. of horn shavings per acre, and a good coating of silicate of lime.

"No. 8.—From the main drain in the Inner Field at Lower House. This was drained in the winter of 1854–55. It was previously coppice or larch plantation. After draining it was planted with hops, which were manured last summer with 6 cwt. of guano per acre.

"All the above drains are from 4 to 5 feet in depth."

These different waters were placed in three gallon jars, carefully sealed, and forwarded at once to London for analysis. Some of them were turbid, as Mr. Paine observes, but this was principally with clay, although no doubt some portion of organic matter in *suspension* may, under such circumstances as he describes, be carried off in the drainage water. It must be distinctly observed that all the analyses given in the paper were made after the samples were *carefully filtered* and rendered perfectly clean and bright. I have to do here with the substances which may be removed from the land *invisibly*, and not with those which are palpable to the eye.

Instances could certainly be adduced where drains have been known to run with water obviously coloured by manure, but

these are the exception, not the rule; and it was my object to detect the subtle and insensible loss which might occur to land where no indications except those furnished by chemical analysis could have marked its existence.

The following Table exhibits the analysis of the seven first samples described by Mr. Paine, so far as relates to the mineral constituents properly so called. These are all the mineral analyses of drainage-waters that I have yet made. The quantity of ammonia, nitric acid, and organic matter, will be stated immediately:—

TABLE III.—Water of Land Drainage—Mineral Contents.
(Grains in an imperial gallon.)

	1.	2.	3.	4.	5.	6.	7.
Potash	trace	trace	0·02	0·05	trace	0·22	trace
Soda	1·00	2·17	2·26	0·87	1·42	1·40	3·20
Lime	4·85	7·19	6·05	2·26	2·52	5·82	13·00
Magnesia	0·68	2·32	2·48	0·41	0·21	0·93	2·50
Oxide of Iron and Alumina	0·40	0·05	0·10	none	1·30	0·35	0·50
Silica	0·95	0·45	0·55	1·20	1·80	0·65	0·85
Chlorine	0·70	1·10	1·27	0·81	1·26	1·21	2·62
Sulphuric Acid	1·65	5·15	4·40	1·71	1·29	3·12	9·51
Phosphoric Acid	trace	0·12	trace	trace	0·08	0·06	0·12

Upon examining this Table we find that the substances which are found in drainage-water in largest proportion are lime, magnesia, soda, and sulphuric acid. That the quantity of lime should be considerable in some instances, especially where, as in the district in question, the land contains so much of it, should hardly surprise us. Carbonic acid, which exists in rain water, and is furnished in large quantity by cultivated soils, readily dissolves carbonate of lime, and the great bulk of the water of the chalk district comes in this way to contain from 15 to 20 grains of this carbonate in the gallon. The sulphuric acid, which to a great extent occurs in the waters in the form of sulphate of lime, may either exist in the soil in that form, or may have resulted from the use of superphosphate, which always contains large quantities of sulphate of lime. It might also be liberated from the various substances of an animal nature, such as horns, hoofs, rags, &c., which Mr. Paine uses, and which contain sulphur.

The quantities of soda and magnesia are in some cases rather large. They must, I imagine, have been derived from the soil, for apparently no portion of either has been applied in manure. It will presently appear that, in all probability, the presence of these substances in quantity is connected with that of nitric acid.

In some instances we find a good deal of chlorine (as common salt).

Oxide of iron and silica are found in the waters in small proportion. They are not of much importance in a practical point of view.

But if we turn to the only two substances which from their known influence as manure, and their *relative* deficiency in soils, or cost when added, we should consider of the first importance in this inquiry, namely, phosphoric acid and potash, we are gratified to find that they are present in the waters in remarkably small quantity only. In four out of seven cases the potash was so small in quantity that it could not be estimated; in No. 6, which contains the most, it is only present to the extent of two-tenths of a grain per gallon. The same is true of the phosphoric acid, which, in three instances out of seven, could not be determined on account of its smallness in quantity. No. 7, the extreme case, reaches only one-tenth of a grain per gallon. It must not be imagined that by the word *trace* it is meant to imply that there is no potash or phosphoric acid to be found; it is merely to be understood that it is so small that there is no possibility of determining it; and, inasmuch as in the other cases the quantity has been ascertained, it is obvious how small must be that portion with which we are unable to deal.

I propose presently to show what quantities of the different substances named are carried off by the whole drainage of the year, and it will then be seen how practically unimportant is the loss of phosphoric acid and potash from this cause.

We will now see what are the facts in regard to organic matter, nitric acid, and ammonia.

The following Table gives the quantity of these substances in the eight samples of water received from Mr. Paine:—

TABLE IV.—Organic Matter, Ammonia, and Nitric Acid in Land Drainage Waters, from Mr. Paine.

(Grains in the imperial gallon.)

Number.	Soluble Organic Matter.	Nitric Acid.	Ammonia.
1.	7·00	7·17	0·018
2	7·40	14·74	0·018
3	12·50	12·72	0·018
4	5·60	1·95	0·012
5	5·70	3·45	0·018
6	5·80	8·05	0·018
7	7·40	11·45	0·006
8	not determined	3·91	0·018

First, of the "organic matter" contained in drainage-waters, as exhibited by this Table. That it is in some instances very

considerable is obvious; but it is to be mentioned that this organic matter does not contain any, or at most very little, nitrogen—a fact which I carefully ascertained in one or two instances. It is, therefore, of the carbonaceous nature, that is to say, resembles woody fibre and gum, or humus in a soluble condition. And although it is *pro tanto* a loss to the soil, its importance is not very great. I am inclined to think too that it is in great part derived from the roots of furze, wood, or grass, which must have been in the soil in large quantity when the ground was first drained and broken up; and this idea, which is shared by Mr. Paine, from his knowledge of the nature of the soil, is further corroborated by the fact that the largest quantity (12½ grains per gallon) is found in No. 3, the history of which land is tolerably evident from the name, "Furze-field," which it bears.

Leaving for an instant the question of nitric acid, let us turn to the third column in Table IV., which exhibits the quantity of ammonia. It will be found that the largest quantity of this alkali in any of these drainage-waters does not reach $\frac{2}{100}$ths of a grain in the gallon; that this quantity is remarkably small will be seen when we reflect that a gallon contains 70,000 grains; and consequently the ammonia will be equal only to 1 part in 3½ million parts of water. This circumstance also shows how accurate and careful must be an analysis which can afford any satisfactory result on such a subject. The fact is, and in this consists the secret of the similarity of the figures above, that we are not able to say absolutely what quantity of ammonia is present in such cases; all we can say is, that it is more than so and so and less than so and so; thus the number 0·018 in the column we know expresses the maximum of ammonia in several of the samples, but it may be any less number between that and 0·012, and in like manner with the others.

I cannot help feeling considerable satisfaction at a result which so completely bears out my conclusions with regard to the absorptive powers of the soil for this alkali (ammonia) as does this comparative absence of ammonia from drainage-water. That it could not be *entirely* absent, I have long ago explained; but it will be obvious presently, when we calculate the annual loss occasioned by drainage-water, that at all events there is practically no loss of ammonia from this cause.

It becomes necessary now to revert to the column 2, in which the quantity of nitric acid is given; and here—knowing that nitric acid is a compound containing nitrogen, that all-important element of vegetation—and considering how very great in some cases, in the Table, the quantities of nitric acid are—we might be seriously impressed with the significance of the fact, were it

not that we know that these waters are extreme instances, and that in all probability such a loss rarely if ever occurs in ordinary farming. Instances will very shortly be adduced in confirmation of this fact; and in the meanwhile it is to be borne in mind, that Mr. Paine is in the habit of using on his land large quantities of such substances as hair, horn-shavings, woollen rags, &c., to which in all probability this large quantity of nitric acid is to be referred.

As far as our present knowledge goes, we must view the nitrogen of nitric acid (nitrates) in the same light as to agricultural value as that of ammonia. All recent experiments—amongst others, those of the late Mr. Pusey—seem to point to this conclusion. Indeed the French chemists are going further, several of them now advocating the view, that it is in the form of nitric acid that plants make use of compounds of nitrogen. With this view I myself do not at present coincide; and it is sufficient here to admit, that nitric acid in the form of nitrates has at least a very high value as a manure. What then must we think of drains running gorged with water, every gallon of which contains as much as 12 or 14 grains of nitric acid?

Fifty-four parts of nitric acid contain the same quantity of nitrogen as 17 parts of ammonia, or, in round numbers, 3 parts of this acid represent 1 part of ammonia. Consequently, in the samples Nos. 2, 3, and 7, we have a value equal to 4 grains of ammonia or about 24 grains of guano in each gallon of water.

Before proceeding further in this calculation, it will perhaps be well to take other instances, which will serve materially to modify the feeling of alarm which such a state of things is likely to create. The samples sent to me by Mr. Acland were a series of twelve, judiciously selected; of these I have only as yet been able to examine six or seven, and those only for nitric acid and ammonia; indeed, as Mr. Paine's samples represent land of the highest degree of fertility, and excessively manured, we may almost consider it as a settled point that no practical loss of phosphoric acid or potash, the most important mineral substances, occurs in drainage, and that further analyses for such substances are unnecessary, unless it be to ascertain whether any deviation from this rule occurs either in the case of shallow drains or poor sandy soil.

The samples from Mr. Acland as yet examined are thus described:—

"No. 1.—Poor clay tillage field. (Hatchclose on Newland.)—Drained about six years since. Summer before this young grass dressed with dung; fallowed for turnips; present crop now in ground manured with dung and 1½ cwt. of superphosphate, also with guano and wood ashes; drained with 2 inch pipes, about 3 feet deep; water continually running for last three weeks."

This sample contained in the imperial gallon, in grains—

Nitric acid	4·78
Ammonia	0·003

"No. 1, B.—Poor clay tillage field. (Gratton on Newland.)—No manure last year; wheat about 7 bushels per acre this year, being very poor naked fallow, drained with 2 inch pipes 3 feet deep; continually running for last three weeks."

This sample contained—

Nitric acid	2·99	in the imp. gall.
Ammonia	a trace	

"No. 2, A.—Shelving pasture on Newland. (Clay.)—No manure; not watered; drained last year with 2 inch pipes 3 feet deep, continually running ever since."

Nitric acid	0·628	grs. in the gall.
Ammonia	0·012	

"No. 2, B.—Clay water meadow. (Sprydon.)—Well watered every day with wash from a dwelling-house."

Nitric acid	0·12
Ammonia	0·012

"No. 3, A.—Pasture sandy soil. (Mr. Joe Salters, Ham.)—No manure; drained with 3 inch pipe 4 feet deep last year; water not stopped running."

Nitric acid	0·485 per gall.
Ammonia	trace.

Another sample from Mr. Acland (No. 5 A) contained 1·97 grains of nitric acid in the gallon. Four samples of water from Mr. Wren Hoskyns were analyzed for nitric acid—unfortunately having been sent to the railway on a very wet day, the labels were obliterated, and there were no means of distinguishing the samples from each other. These samples gave respectively of nitric acid in the gallon 4·63, 4·40, 1·10, and 1·17 grains. The following is Mr. Hoskyns' description of these samples.

No. 1. "The Twelve-Acres."—A strong soil on clay bottom, very flat. Drained (3½ feet deep) in 1851. Ridges lowered after drainage. A two-years' clover-ley broken up for wheat in November last. 2 cwts. of guano and an equal bulk of salt, to the acre, applied after the drill. It had been sheeped all the summer, but not dunged from the fold.

No. 2. "The Croft."—A rather thin-soiled field of medium texture; drained 3 feet deep in 1845. Turnip-fallow after wheat; limed 15 qrs. to the acre and dunged from the fold-yard. Superphosphate drilled with the turnip-seed, on the ridge.

No. 3. "Lower Brick-Kiln Close."—A moderately stiff soil, furrow-drained 3 feet deep in 1844. A wheat-stubble autumn-ploughed for beans. The wheat had been dressed with 2 cwt. of guano, half at sowing-time and half top-dressed in spring.

No. 4. "Black Piece."—A peaty soil on gravelly and sandy clay subsoil; drained 30 inches deep in 1843. A clover-ley after wheat; not manured.

The drainage-water was taken from the four fields on the same day, the 21st of January last, after and during very rainy weather.

It is pretty plain which were the samples from manured land.*

We have now before us the determinations of ammonia in some 12 or 14 samples of drainage water, and that of nitric acid in a considerably large number, and we may fairly come to some conclusion on the subject. With regard to the former there can be no manner of doubt—from soils rich or poor, manured or not manured, it is all the same, the quantity of ammonia in no case exceeds $\frac{8}{100}$ths of a grain in the gallon. I regard this as conclusive, and believe that unless in very exceptional cases, and where the manure *visibly* runs into the drains—probably through cracks in the soil—we shall not find ammonia in quantity in the waters of drains.

With nitric acid the case is different. In the instances before us we have it in all sorts of quantities—from $14\frac{3}{4}$ grains in Mr. Paine's sample No. 2 to $\frac{12}{100}$ths of a grain in Mr. Acland's sample 2 B. The presence of nitric acid in some proportion in drainage water would seem to be universal, for of nearly 20 samples examined not one is free from it. But we may well ask at what point are we to fix the natural or ordinary quantity of this substance carried off in drainage water. To that question I am as yet not prepared to offer an answer. I have said before that this must be considered in the light of a preliminary inquiry—settling some matters and leaving others open for further investigation. Amongst these latter the principal are the variations from time to time throughout the year and the manures which more or less give rise to nitric acid.

Attention was called just now to the variation in the quantity of soda and magnesia in Mr. Paine's samples, and it was suggested that they would be found in all probability to be connected with the proportion of nitric acid. In effect if we examine the Tables we shall find that such is the case—wherever the proportion of nitric acid is large, there also the proportion of soda and magnesia is large—the converse being also observed. The remark applies perhaps more truly to magnesia than to soda, which latter alkali is dependent to a great extent on the quantity of chlorine present, in combination with which it occurs as common salt.

The connection of nitric acid with alkalies or earths in drainage water is simple enough—if a substance containing nitrogen undergoes oxidation in the soil with the production of nitric acid, this latter cannot be supposed to pass through the soil to the drains without neutralization—it therefore unites with lime, mag-

* As the wheat crop of last year had probably taken up the guano dressing in No. 3, and the field was not manured before the autumn ploughing, I have little doubt that the order in which I have numbered the fields corresponds with that in which Professor Way has given the figures stating the results.—C. W. H.

nesia, soda, or some other base, and we find it in combination with these in the drainage water.

The production of nitric acid and its removal by drainage water may be considered as a double evil, inasmuch as it necessarily carries with it some one or other of the alkaline bodies. In the absence of those more common and to vegetation less important alkalies, lime and soda, this nitric acid would be the means of carrying off from the soil a portion, and perhaps considerable portion of its potash or even its ammonia; but in all probability such a result would be of rare occurrence.*

I have alluded to the importance of ascertaining by examination made at different seasons to what extent this removal of nitric acid from the soil was constant or at all to be compared with that which a sample taken at any one time might lead us to suppose. We are not altogether without information on this subject.

Mr. Paine's sample, No. 7, taken on the 27th December, contained 11·45 grains of nitric acid in the gallon. On the 4th April of the present year, or rather more than three months afterwards, when the drains, having never ceased, were still running, although of course in diminished quantity, the water was found to contain 7·57 grains of nitric acid in the gallon.† It is evident, therefore, that the quantity of nitric acid removed from the soil by drainage was decreasing. But we have already seen (Table I.) that in the month of April the proportion of water filtrated through the soil begins to diminish, whilst in the next month it is reduced to about 5 per cent. of the whole, and in the next month to somewhat less than 2 per cent. We may fairly conclude, therefore, from the composition of the drainage water at these two periods (the latter end of December and the commencement

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* I cannot help regarding these analyses of drainage-water as a strong confirmation of the general truth of my previous results with regard to the chemical phenomena of absorption in the soil, not only for ammonia, but in gradation for each base in the soil. In a supplement to his 'Principles of Agriculture,' Professor Liebig takes occasion to review the facts developed by my experiments on the 'absorptive power of soils,' which facts he proposes to show, at once, were well known, and have no foundation in truth. My experiments on double silicates are characterised as "theatre decorations," and such information is called giving "a stone where bread is asked for" by the farming body, which is, according to Professor Liebig, justified "in taking shelter from such chemical teaching in a wholesome empiricism."

The translation of these criticisms of Baron Liebig has for months been in circulation in America. I have every hope that when a second edition of the 'Principles' is published in England, the Supplement will also appear. Should there be no sign of any such publication, I shall take means to lay the whole question before the agricultural public.

† Since the above was in type, I have received from Mr. Paine a third sample of this same water. It was collected on the 11th June, when the drain was running very slowly, about one quart per minute. Upon analysis it was found to contain 7·02 grains of nitric acid per gallon.

of April) that the drainage of the whole year on this particular soil would as regards nitric acid be somewhere intermediate between the two numbers above given—11½ and 7½—that is to say, about 9 grains in the gallon. For the sake of illustration, I will suppose that in this field of Mr. Paine the annual flow of drainage water (240,479 gallons) carried off in each gallon 9 grains of nitric acid; we shall find that this quantity is equal to 309 lbs. of nitric acid, which would be contained in about 515 lbs. (or about 4½ cwt.) of commercial nitrate of soda, worth, at its present price, about 4*l.* Supposing, however, only one grain of nitric acid to be removed in each gallon of water for the whole drainage of the year, we shall have a quantity of rather more than 34 lbs.

Whilst we may assume that there is an indefinite but constant loss to the soil in the shape of nitric acid, we find on the other hand that the loss of ammonia, if calculated at its fullest, does not exceed half a pound per acre in the drainage of the whole year. This quantity is of course quite unimportant, and we shall presently see that it is more than compensated by other natural causes.

The quantity of potash removed from a soil in the whole drainage is also very insignificant. The largest quantity indicated by the analyses is 0·22 (or about one-fifth of a grain) in a gallon, which, on the previous calculation, would amount in one instance (No. 6, Mr. Paine's sample) to about 7½ lbs. in the whole drainage of the year—this being, however, very much larger than in any other of the specimens exhibited.

It is to be remembered that as the drains are at a depth of from 4 to 5 feet, all the soil to that depth is concerned in furnishing the substances which we find in the water. Assuming a superficial inch of soil, over an acre, to weigh 100 tons, and that the drains lie at only 40 inches from the surface, we shall have 4000 tons of soil, subject to the solvent action of the water; and we shall find by calculation that the quantity of potash removed from the soil in the year by drainage would be represented by the decimal ·00001 per cent.—that is to say, that if the whole of the soil were analysed before and after this quantity (7 lbs. per acre) was removed, there would be found no greater difference than the hundred-thousandth part of a grain in every hundred grains of soil, supposing it possible, which it is not, for analysis to detect it. Now, as there are probably very few soils that would, on analysis, exhibit the presence of so little as one-tenth per cent. of potash, it is plain that the drainage-water would in effect remove only one part of ten thousand parts existing in the soil. It is only on a consideration of numbers and quantity that we can appreciate some facts at their true worth;

and we see in this instance how very much we may be misled if we neglect these circumstances in forming an opinion.*

The same remark holds good with regard to phosphoric acid. The largest amount of this substance which, in any of the instances, would be found in the drainage of the year, is 4 lbs., which is equivalent to about 8 lbs. of phosphate of lime, a quantity which the decimal just given for potash would equally represent.

It may be thought that this reasoning should be extended to nitric acid; but apart from the fact that the quantity of this substance is so enormously large, as compared with the potash and phosphoric acid, it is to be remembered that nitric acid does not, like them, exist in the soil, but is in all probability a product of the manure applied, and as such a direct loss.

We turn now to the subject which forms the next division of our inquiry—

3rd. *Whence are these substances derived?*

That all the mineral matters found in drainage-water are derived either from the soil or the manure added to it there can be no question. With the exception of some one or two substances (such as common salt), which are carried mechanically in the air from the ocean, we do not find in rain-water any appreciable amount of mineral matter. But this is not so obviously the case with ammonia and nitric acid; in fact, we very well know at the present time that both these substances do exist in rain-water; and should it so happen that their quantity were sufficient, we might readily attribute the presence of these compounds of nitrogen in drainage-water to the rain.

That the ammonia in rain equals in quantity that in drainage-water seemed credible enough, but it would hardly be anticipated that so great an amount of nitric acid should be found in rain-water; and indeed the circumstance that in one sample of drainage-water there should be but half a grain or less per gallon, and in another as much as 14 grains, seemed very much opposed to such a view. However, it was absolutely indispensable that all doubt on this point should be removed; and for this purpose it became necessary to institute a careful examination of rain-water itself.

I must briefly recall to the memory of my readers some circumstances connected with this question of the composition of rain-water, which I brought before them on a previous occasion.

* We must, however, in the case of highly cultivated soils be equally guarded, on the other side, against multiplying *quality by quantity*. There are few soils in England upon which a calculation of the potash, or any other manurial substance not specially abundant, could be assumed as constant, from the cultivated surface to the depth acted on by 4-feet drainage.—C. W. H.

In France especially a great deal of attention has lately been paid to the subject, and names of the highest note in chemical science are associated with its investigation and discussion. In a very able paper, M. Barral recorded experiments which for the first time had been made by him for the estimation of ammonia and nitric acid in the rain-water of Paris. M. Boussingault repeated M. Barral's experiments (so far only as *ammonia* was concerned), and found them perfectly correct for Paris, but totally inapplicable to rain falling in the country, which latter contained very much less ammonia.*

Messrs. Lawes and Gilbert entered into the subject in England with their usual spirit; and having made special arrangements for the collection of rain-water falling at Rothamsted, they carefully examined the different methods of determining ammonia in water, as practised at the time, and obtained a series of results, which were reported to the British Association in the year 1854. But, finding that the methods which were available for the determination of nitric acid were anything but trustworthy, and that the results which they obtained were conflicting and unsatisfactory, they very wisely forbore from publishing them.

The possession of an accurate process for the determination of minute quantities of nitric acid gave me, however, in the spring of the present year, the opportunity of approaching this question with some prospect of success; and Mr. Lawes, with a liberality which cannot be too much admired, placed at my disposal a complete series of the rain-waters of each month of the year 1855. Through his kindness, therefore, I am now in the position of placing before the agricultural public for the first time a reliable statement of the composition of the rain of a whole year, so far as regards the ammonia and nitric which it contains, as collected in the open country. However interesting the drainage results may be found, I attach to this part of my

* I have examined samples of rain-water, falling at the back of my house in London. The water was collected in a large painted sponging-bath. After filtration, so as to remove the sooty matter, it was examined for nitric acid and ammonia.

The first sample, collected on the 11th of April, in the present year, during a short shower, gave me 0·09 of nitric acid per gallon, or about the same as was found in the water of June collected at Rothamsted, as will be seen further on. The second sample, collected May 1st, gave me 0·12 nitric acid, or rather more than the first, but it was found to contain 1·077 grains of ammonia per gallon,—a quantity more than ten times as great as that found in the rain-water of the country. So far, therefore, my results on London rain do not bear out M. Barral's experiments on that of Paris: and unless there be some cause connected with the difference of fuel employed in the two capitals (one being coal and the other wood), I should be inclined to think that M. Barral's determinations of nitric acid were in error from the faultiness of the method to which he was compelled to have recourse.

Paper a still greater importance, inasmuch as the facts now ascertained have a large and comprehensive meaning, and are intimately associated with both the philosophy and practice of agriculture.

The methods which I have employed for the determination of nitric acid and ammonia in rain-water will be found fully described in an Appendix to this paper. We shall here therefore occupy ourselves only with the results.

The rain gauge used by Mr. Lawes at Rothamsted is of a very large size, being of an area exactly $\frac{1}{1000}$th of an acre. The water falling in this gauge is accurately weighed morning and evening. In the 'Gardener's Chronicle,' and elsewhere perhaps, Mr. Lawes has published from time to time the results of his observations, and it may be remarked in passing, that by comparison with an ordinary small gauge, the large collecting arrangement is found to indicate a rain-fall larger by several inches in the year. The gauge, which is of wood, lined with lead, is placed in the centre of a field far from any source of contamination, at more than 20 miles from London, and about 4 miles from the nearest market town, which is St. Albans.

The series of waters supplied to me by Mr. Lawes represented the whole rain-fall of each month in the year 1855. That is to say, the water falling on separate days during each month has been mixed together, and upon a portion of this mixture the analysis has been made.

The following Table shows the amount in grains of nitric acid and ammonia in an imperial gallon of the rain of different months:—

TABLE V.—Nitric Acid and Ammonia in Rain-water, 1855.
(Grains in the imperial gallon.)

	Ammonia.	Nitric Acid.
January	0·092	0·017
February	0·104	0·042
March	0·086	0·021
April	0·123	0·035
May	0·080	0·035
June	0·135	0·080
July	0·061	0·017
August	0·080	0·060
September	0·095	0·021
October	0·061	0·036
November	0·054	0·018
December	0·067	0·017

It will be seen from this Table that the quantity of ammonia in the rain of different months varies considerably, being in June as much as 0·135 grains in a gallon (1·93 parts in a million), and

in November only 0·054 (0·771 parts in a million), or hardly more than a third. The mean quantity for the whole year is 0·086 grains in a gallon, or about 1·228 parts in a million of water.*

A glance at the column for nitric acid will show how small is the quantity of this substance brought down by rain. Considerable variations are observable in this as in the other case, the quantity being in June five times as great as in several other months. The mean quantity is seen to be 0·0315 grains in a gallon, or 0·405 parts in a million of rain.

Before attempting to draw any conclusions from this Table it will be well that we should place the matter in its true bearings, by connecting the quantity of ammonia and nitric acid in the rain-water of different months with the quantity of rain which fell in those months. From data furnished me by Mr. Lawes I am able to calculate the number of gallons of rain falling on an acre of land at Rothamsted in each month of the year 1855, and knowing the proportion of nitric acid and ammonia per gallon, nothing of course is easier than to ascertain precisely the total quantity of these substances which was brought in aid of vegetation by this means.

The Table given below affords these particulars. I have added a column to show the total quantity of nitrogen in the rain, whether existing as ammonia or nitric acid.

TABLE VI.—Nitric Acid and Ammonia in Rain-water, per acre, 1855.

—	Gallons of Rain.	Nitric Acid in Grains.	Ammonia in Grains.	Total Nitrogen in Grains.
January	13,523	230	1244	1084
February	22,473	944	2337	2169
March	52,484	1102	4513	3995
April	9,281	325	1141	1024
May	52,575	1840	4206	3939
June	41,295	3303	5574	5447
July	157,713	2680	9620	8615
August	59,622	3577	4769	4870
September	34,875	732	3313	2917
October	124,466	4480	7592	7414
November	55,950	1007	3021	2749
December	39,075	664	2438	2180
Total in lbs. whole year ..	..	2·98	7·11	6·63

The results in this Table are interesting not only on account of the light which they throw upon the question of drainage, but

* The experiments of Mr. Lawes and Dr. Gilbert, in 1853 and 1854, gave as a mean, as nearly as possible, 1 part of ammonia in a million of rain. Boussingault's result in Alsace was about 3-4ths that of Lawes and Gilbert.

from their connection with other subjects which have lately attracted so much attention. If we are to believe these figures (and my own faith in them, founded on the care which has been bestowed upon the analysis, is complete) we must at once conclude that the various estimates which have been formed for the last two or three years on the quantities of ammonia and nitric acid in rain are totally erroneous. We have been under the impression that this quantity might very fairly be held to account for the natural fertility of an unmanured soil. M. Barral's experiments in Paris first gave rise to this impression, and an examination of the rain falling at Pusey, by myself, seemed to confirm his results.* It seems now, however, that the methods of analysis for nitric acid were defective, and that no reliance can be placed either upon such analyses or the conclusion drawn from them. In point of fact the quantity of nitric acid brought down by rain, instead of being much greater than the ammonia, is actually far less, and the total quantity of nitrogen in either form does not, as we see, exceed 6⅝ lbs. in the whole year. This quantity is equal to 8 lbs. of ammonia, and would be furnished by 35½ lbs. of sulphate of ammonia, or 47 lbs. of guano. We can hardly, therefore, with these facts before us, continue to believe that the rain brings down nitrogen enough to account for a normal or natural fertility, or the growth of 14 to 17 bushels of wheat from year to year.

I fear too that we must abandon the pleasant notion that the refreshing effect of an April shower is due to these compounds of nitrogen, since the rain of the whole month only contributes 1000 grains of this element, equal to about 1 lb. of guano to each acre of land.

It must not be supposed that I mean to deny that the ammonia and nitric acid in the air are all-important agents in vegetation, or that they are sufficient, without recourse to the doctrine of the assimilation by plants of free nitrogen, to account for all the phenomena observed. What I do mean, and what I have frequently before said is—that we must seek elsewhere for the measure of this influence, that the rain-water does not form a trustworthy guide, and that it is in the air rather than in the water that we shall find the chief quantity of these fertilizing agents. The rain falls at certain periods only; in the intervals the nitric acid and ammonia are not accumulating, they are removed by vegetation and by the influence of the soil. I

* I regret that this analysis should have been published—at all events, without the caution which, in my Report upon it, I recommended with regard to the adoption of the figures. I was perfectly aware of the unsatisfactory character of the methods which I employed, although they were the best then existing.

attribute to such removal far more force than to the occasional and uncertain influence of rain.

There is another circumstance that points to the same conclusion. Every acre of ground which allows water to percolate freely, benefits equally by the nitric acid and ammonia of rain. But whence comes the additional luxuriance which vegetation puts on when the land is abundantly worked? whence the Lois Weedon crops? Obviously Mr. Smith cannot be satisfied with the ammonia of rain, he must have some from the air also; and he does get it from the air in far greater quantity than the rain could furnish.*

If we examine the Table we shall find the facts to bear out this view. There is a general, though not uniform relation between the quantity of ammonia and nitric acid in the month, and the quantity of rain that has fallen in that month. Thus in July we have the largest rain-fall (157,713 gallons), and by far the largest quantity of nitrogen (8615 grs.). In October the next largest fall of rain, accompanied with a corresponding quantity of nitrogen. In April we have the smallest rain-fall and the smallest quantity of nitrogen; and January follows it exactly in the same relation.

That the rain-fall and nitrogen are not more closely related in quantity is probably due to a modification, which the comparative number of times at which the rain falls would introduce.† The bearing which the figures in the foregoing Table have upon the drainage question may be stated in two words. In the first place, by comparing them with those given in the Table of drainage-water, we find that, as far as ammonia is concerned, the quantity falling in rain greatly exceeds that which passes off by the drains; thus, although in no case do we find ammonia in drainage-water to a greater extent than 0·019 per gallon, in rain-water we have no instance where it is less than 0·05; whilst the mean is 0·086, or four times as much as the largest amount in drainage-water. It is obvious, therefore, that instead of being an agent for the abstraction of ammonia from the soil, rain, on the contrary, carries off (by drainage) less than it brings; a fact again proving the power of the soil in absorption. But with nitric acid it is different. The quantity of this substance present in rain-water is not enough to account for that found in any one of the drain-waters examined; and if we take

* Mr. Smith habitually expresses his obligations to *the dew*, as a more steady benefactor than the rain, in much the same terms as might express the relation of "daily bread" to an occasional feast.—C. W. H.

† It has been usual to suppose that the nitric acid of the air is due to electrical action. If so, it is obvious that this force is in continual exercise, since we find nitric acid present in the rain of every month of the year.

one of the instances of waters collected by Mr. Paine, say, for instance, the sample No. 7, which contained upwards of 11 grains of nitric acid in the gallon, we shall see how very short the rain-fall is of accounting for this quantity. In effect, the whole quantity of nitric acid falling in rain at Rothamsted last December was 664 grains, which would be contained in 60 gallons of the drainage-water collected at the end of that month at Farnham; whereas nearly 20,000 gallons of water must have passed through the drains of each acre of land during the two days when the samples were collected, a quantity which must have carried with it upwards of 200,000 grs. (30 lbs.) of nitric acid.

One question for which these rain-waters were examined is answered. The nitric acid brought down by rain is totally inadequate to account for that found in drainage-water. Is it then formed in the soil from the nitrogen of the air? or abstracted from the air by the soil? or is it derived from manure?

With the two former of these questions we need hardly trouble ourselves, since the third supposition is capable of an answer so decidedly affirmative.

There is no doubt that when air containing nitric acid in the state, as it would be, of nitrate of ammonia, comes in contact with the soil, the nitric acid would be retained by the soil, and thus a quantity of this substance might be accounted for.

Again, it is possible that, under the influence of the porous soil and the alkalies which it contains, the nitrogen of the air may be oxidated; and, in the absence of better reasons, we might fly to either of these for an explanation of the nitric acid in drain-water; but in the instances before us the effect is too plainly traceable to manure.

If we compare the analysis of the samples from Mr. Paine with the history of the fields, we shall find that the largest quantity of nitric acid (namely, 14, 12, and 11 grains per gallon) is found where the land had been heavily manured with horn-shavings, rags, rabbit-skin waste, or some such animal substance. On the other hand, in two samples from Mr. Acland, where no manure had been applied, we find the nitric acid barely exceeding ½ a grain in the gallon.

Again, of four soils, in other respects alike, from which water was collected by Mr. Wren Hoskyns, the two, which had received guano, furnish water containing 4½ grains of nitric acid per gallon, whilst those which had not been so treated contain only about 1 grain each. I fear that this evidence is too strong to permit a doubt that it is the nitrogen of manure that is thus running in the drains.*

* On the 12th of November, that is, six weeks before the samples of water were collected, Mr. Paine sent me several soils for examination, in aid of another inquiry

The next question is, how is this production of nitric acid from manure brought about? This may possibly happen in several ways. The substances may in the act of decomposition give rise through their nitrogen to nitric acid, which may subsequently be washed through the soil, taking with it any alkali it happens to meet.

Or, in the progress of its putrefaction the nitrogenous matter may by filtration be converted, as Dr. Angus Smith has shown, into nitric acid.

Or, lastly, the nitrogen may first form ammonia, which may subsequently be oxidized into nitric acid. I believe the first of these suppositions to be the most reasonable. The production of nitric acid by filtration of putrid animal matter, as shown in the very interesting experiments of Dr. Smith, applies rather to sand (and especially to charcoal) than to soil, because the latter arrests such matters, and so soon as this happens the production of nitric acid would, I believe, be out of the question. In fact I have failed to obtain nitric acid by filtration of putrid matters through soils. This subject, however, requires further examination.

The conversion of ammonia into nitric acid *in the soil* I am very unwilling to believe. It is by no means easy to produce this result when the ammonia is out of the sphere of other influences, and the strongest oxidating substances are unable to effect it;* but when it is united in the soil to substances, such as silica and alumina, this action is still less likely to happen, especially at common temperatures. I have filtered a weak solution of ammonia for days through a column of sand 10 or 12 inches deep, and have not only got no nitric acid in the liquid, but by analysis have recovered all the ammonia originally present. But the production of nitric acid during the decay of highly nitrogenous substances, such as those in question (bones, woollen-rags and such animal matters) when in free contact with the air is well understood, and I entertain no doubt that to this action we must attribute the great quantity of nitric acid in those cases where such manures have been liberally applied. The same remark applies to guano, for it must be remembered that although we are in the habit of speaking of guano as an *ammoniacal* manure, it is by no means the case that the whole of the nitrogen in it exists in the form of ammonia; on the contrary, we know that

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upon which I am engaged. In one of these, taken from a field from which a sample of water was afterwards collected, I found as much as 0·672 grains of nitric acid per lb. This quantity would be equal to 1505 grains (about 1-5th lb.) for each ton of soil, or 20 lbs. for each inch in depth of soil on an acre. If we suppose only 12 inches of soil to contain this proportion, we should have 240 lbs. of nitric acid per acre *actually* in the soil at that time: a quantity quite sufficient to account for that subsequently found in the water.

* The permanganate of potash does not, I find, even when boiled with a solution of ammonia, give rise to any nitric acid.

one of its principal ingredients is uric acid, a compound containing nitrogen not in the condition of ammonia. It is therefore quite possible that under certain circumstances guano may give rise to the production of nitric acid which the drainage-water may carry off; and this observation brings us to the last head of our inquiry, namely—

What circumstances are likely to increase or diminish the waste from such causes?

In a great degree this question must be left for ulterior examination; a knowledge of the cause of the production of nitric acid in the soil will naturally lead to a remedy for its prevention, supposing such a remedy exists; at present, however, as we have just seen, the cause is not so obvious.

The two points to decide are, Does organic matter containing nitrogen give rise to the production of nitric acid by filtration through *the soil?* and, Is ammonia oxidated by such filtration? If these questions are answered in the negative, then I think we shall find a practical solution of the only other difficulty, which is, the oxidation of the manure into nitric acid during its decay.

It is generally agreed that the first stage in decomposition is the production of ammonia, but that in the absence of any substance to unite with this ammonia, it passes, in the presence of excess of air, at once into nitric acid. We can readily understand then, that a nitrogenous substance undergoing putrefactive fermentation by itself would give rise to nitric acid; and such would be the case with all manures, such as bones, rags, &c., which by their very nature cannot but lie in masses of more or less size. It may be however, that if these substances could be reduced to a comparatively fine condition and then intimately mixed with the soil, that the production of nitric acid would in great measure be obviated. In this latter case, the soil having the power to unite with ammonia would arrest the action at that point. It may seem possibly in opposition to this view, that manuring with guano should give rise to nitric acid, as it is seen to do in the case of Mr. Wren Hoskyns' samples; but it may well be doubted whether the mixture of this manure with the soil in the ordinary system of broad-casting is by any means so perfect as is desirable, and in all probability the cause is the same in both cases.* As I said before it is better to leave this matter open at present until further experiments have demon-

* This is one of the grounds on which I am led to the practice of mixing the guano with an equal bulk of salt, *in the hopper*, at the time of sowing it, after the seed-drill. It certainly helps the act of *distribution* greatly, especially if, according to my practice, the guano be "pounded" very fine beforehand; and the rapid assumption of moisture by salt must, I conceive, favour its more minute dissemination *in* the soil.—C. W. H.

strated the truth of the supposition or shown its fallacy. There can, however, be no harm in urging, as I have often before done, the more extensive adoption of every method which will bring manures into perfect contact with the soil. Foremost in this rank, of course, stands the judicious use of manure in the liquid state; in the absence of this, the next best means of bringing about this combination between the soil and manures, is the method of compost heaps, and it seems to me that advantage might be taken of this plan to a much greater extent than is at all usual. Even in the use of artificial manures, such as guano and superphosphate, I think it would greatly increase the efficacy of their application, if for some time before they were employed they were mixed with a considerable portion of good soil and moistened. In fact I would make a compost heap of guano as is ordinarily done with farm-yard manure. Such an idea may, I have no doubt, find plenty of objections on the score of difficulty, expense, and what not. All the chemist can do is to point out *principles*—if they are inadmissible in practice from some causes of which he is unaware, that is a sufficient reason for not putting them into practice; but if on the other hand his suggestions are not altogether impracticable, sooner or later some intelligent enterprizing farmer will find the means of bringing them to bear.

On the present, as on former occasions, my axiom is, that the more perfect the contact of every particle of the manure with the soil the better will be its effect upon vegetation. How that perfect contact is to be accomplished it is for the practical farmer to realize.

Before concluding this paper it may be of advantage to recapitulate the principal points to which we have been led by the present inquiry. We find then, that through every acre of land, whether naturally or artificially drained, there passes annually a quantity of water equal to 42·4 per cent. of the rain-fall, and that where this latter is 25 inches the quantity of drainage-water is equal to about 240,000 gallons in that space of time. That even where the land is very highly manured this large quantity of water removes from the soil only inconsiderable quantities of the most important mineral ingredients of soils, namely, *potash* and *phosphoric acid*. That the quantity of *ammonia* carried off from land by the drainage-water is also inconsiderable, but that nitrogen in the form of nitric acid is, especially in highly manured land, to be found in very large quantity in the water of land-drainage. That the quantity of nitrogen in the form of ammonia and nitric acid in rain-water is very much smaller than has been supposed, and quite inadequate, of itself, to account for the natural fertility that has been ascribed to it; and that it is to these substances, as existing at all times in the air, and absorbed from it by the soil

and by plants (especially the former), that we must look for an explanation of such natural phenomena. That the quantity of ammonia in rain is greater than in drainage-water, which sufficiently attests the absorbing power of the soil for this alkali; but that the nitric acid in rain does not account for the quantity found in drainage even in the instances where it is present in the smallest quantity. That in all probability this nitric acid is due to the oxidation of the nitrogenous matter of manures, and especially takes place where such manures are of a nature to prevent their perfect admixture with the soil. That, lastly, the practical means which occur to us of preventing so important a loss, are the more perfect admixture of manures with the soil by any method which may best accomplish that end.

I shall take leave of this subject, at present, by suggesting the desirability, where it may be accomplished, of employing the drainage-water of land highly manured, for the irrigation of meadow land in its neighbourhood.*

APPENDIX.

Process for Estimation of Minute Quantities of Nitric Acid.

The difficulties of determining nitric acid with any great degree of accuracy are well understood, and no process has hitherto been known which could successfully deal with the small quantities which are found in rain and other waters.† In the autumn of last year (1855), the process which is now to be described first suggested itself to my mind, but it was not until after repeated attempts, extending over several months, and after numerous modifications, that I was able, in conjunction with my friend and assistant, Mr. E. O. Browne, to bring it to a satisfactory issue. The process itself is based on Professor Bunsen's volumetric method for the examination of oxidizing and deoxidizing agents by the means of iodides, but it depends for its success upon a number of conditions, the fulfilment of which constitutes its merit. Professor Bunsen no doubt sought to include nitric acid amongst the other substances to which he

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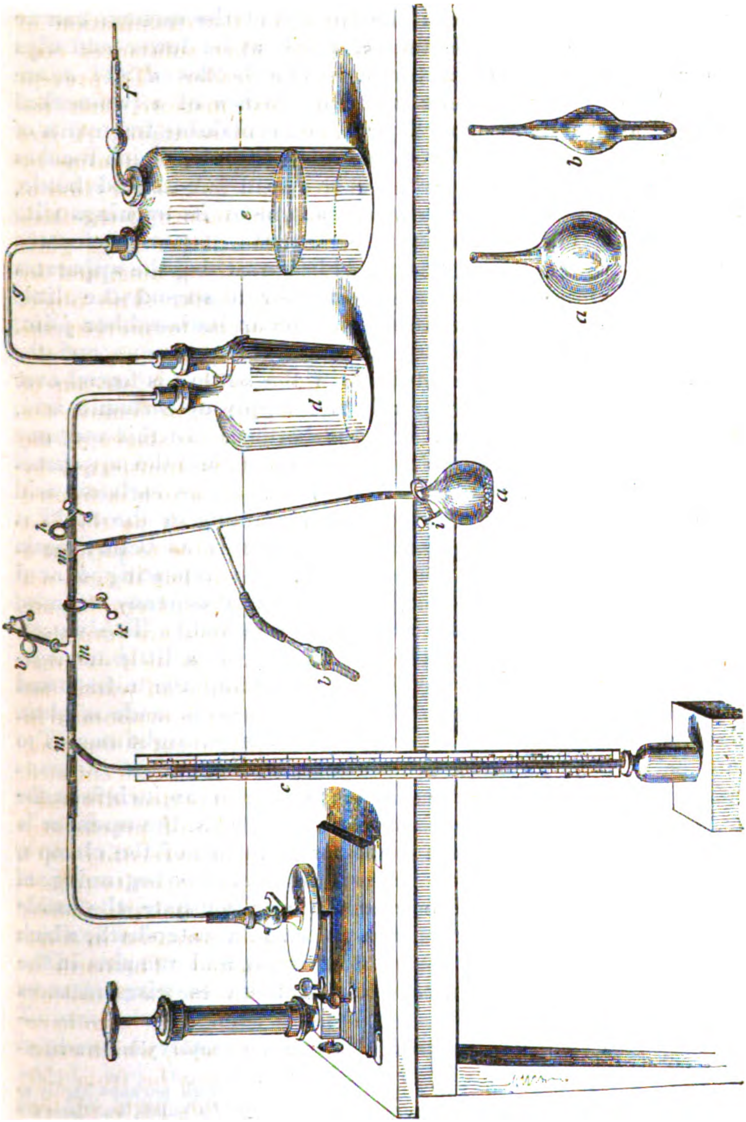
* Such an employment of drainage (surface) waters is well known to exist at Lord Hatherton's at Teddesley, and the Duke of Portland's at Clipstone. Mr. Paine informs me that the drainage-water of some of the fields, where analysis has demonstrated so great a loss of nitric acid, produces the utmost luxuriance in the grass of a meadow over which it is allowed to flow.

† I have already alluded in the foregoing paper to Mr. Ville's method of determining this acid, which, according to the report of the commission appointed to examine the subject, is sound in principle and successful in practice.

adapted his process; but, as he makes no mention of it, we must suppose that he did not accomplish its estimation. I shall describe the process as it is practised in the examination of waters; the modifications necessary for other substances containing nitrates, will readily occur to the reader. To prevent confusion, it will be supposed, in the first instance, that the water contains little or no organic matter in solution. A *pint* of the water is introduced into a flask, and rendered alkaline by a few drops of lime-water, so as to avoid all risk of the loss of nitric acid in the subsequent evaporation; the mouth of the flask is then closed with a cork, furnished with a rather large glass tube, and drawn out to a comparatively small opening, and by means of a lamp it is evaporated to a small bulk. The object of the tube is, by an abundant issue of steam, to prevent the possibility of any circulation in the bottle of the air of the laboratory, which might introduce nitric acid. A stream of carbonic acid is now passed through the liquid, to remove the excess of lime, which is objectionable in the later stages of the process; and the liquid, having been filtered, is transferred by means of a small funnel to a small globular flask, which is figured at *a* in the adjoining woodcut. This flask, as well as the rest of the vessels used in the operation, must be able to support a pressure from without of about one atmosphere, but it need not be at all thick for this purpose. The flasks which I employ are globular, and of about 2½ inches in diameter; they are furnished with necks about 2 inches in length, and $\frac{3}{16}$ of an inch external diameter. They hold when full about 2000 grains of water, but of course not more than two-thirds of this quantity is evaporated in them at the time; the flasks weigh, when empty, about 800 grains, which will serve as a guide to their thickness. The concentrated water is now further evaporated in the flask *a* to perfect dryness; the last parts of the operation being, for the sake of precaution, performed in an air bath, at a temperature not exceeding 350° Fahrenheit. Into the flask is introduced a small quantity (generally for rain-water about 6 or 8 grains) of pure and dry iodide of silver; the quantity of this being of course increased in cases where a larger amount of nitric acid is anticipated. The bottle is now connected with the apparatus, as shown in the woodcut. The little bottle, or tube, *b*, upon which it is convenient to have a bulb, is partly filled with strong hydrochloric acid, which must be free from chlorine; the quantity employed may be from 150 to 200 grains. These flasks, as well as all the parts of the apparatus, are connected by short India-rubber tubes, which, if of proper size, are air-tight without being tied. In using them it is necessary to bring the glass-tubes as nearly as possible into contact, by which the India-rubber tube is prevented from collaps-



Estimation of Nitric Acid (Way.)

ing upon the withdrawal of the air. The acid-tube and globular flask being now in position, a vacuum is made in them by a few strokes of a small air-pump; the amount of the vacuum can be observed by the barometer tube *c*, which at its lower end dips into a small vessel of mercury. The bottles *d* and *e* are intended to supply carbonic acid; *d* consists of a two-necked bottle, of a capacity of about 2 pints, and containing fragments of marble; it is joined to *e* by means of the tube *g*, which reaches nearly to the bottom of each. *e* is also a two-necked bottle, holding about 4 pints, and furnished at one of its openings with a cork and a tube, containing bi-carbonate of potash, for the purpose of preventing any nitric acid from reaching the apparatus from external sources. On pressing for a second the little brass spring clamp *h*, which is placed on an India-rubber joint, the carbonic acid diffuses itself through the apparatus, and the dilute hydrochloric acid contained in the bottle *e* is forced over into *d*, where it gives rise to a further supply of carbonic acid, which forces the acid back into the bottle *e*. In this way any unnecessary waste of the materials is avoided, and the apparatus does not require renewal for a long time.* The carbonic acid mixed with the small quantity of air remaining in the flasks is now removed by the pump, and the vacuum is as before again destroyed by recourse to the spring *h*. By repeating 4 or 5 times these operations, which do not occupy as many minutes, the last portions of air are effectually removed.† The vessels being now nearly vacuous, the acid in *b* is, by a little management, made to flow into the bottle containing the nitrate and iodide of silver. The T-piece connecting these is made of glass. The parts *m m m*, where one tube joins on at right angles to another, are short T-pieces either of glass or metal.

By withdrawing the bottle *a* about a quarter of an inch from the tube connecting it with the rest of the apparatus, the operator is now able to shut it off from the latter by means of the clamp *i*, which is of course placed in readiness at the beginning of the operation. The bottle now containing the nitrate, the iodide of silver, and hydrochloric acid, is placed in a water-bath, which is conveniently supported on a retort stand, and remains in the boiling water for about ten minutes. Under these circumstances

* The same object may be attained by the use of a double cylinder arrangement, such as is employed in the Dobereiner lamp.

† It is quite possible that the air might be removed, though perhaps hardly so effectually by a stream of carbonic acid without the use of a pump, but there are many advantages in the employment of this latter which more than compensate for the extra trouble which it involves in the fitting up of the apparatus, especially that the vacuum enables us to boil the substances in the flask A without risk of bursting, which otherwise would be almost certain to occur if, as it must be, the flask is closed.

the nitrate and hydrochloric acid mutually decompose each other, with the separation of nitric oxide and chlorine; the latter acts upon the iodide of silver, liberating iodine, the vapours of which, when the nitrate present is considerable, will be seen to fill the flask. When the operation is supposed to be complete, the flask and its contents are allowed to become perfectly cool, or may be dipped into cold water to hasten this period. The clamp I is now shifted, and the neck of the bottle restored to its place in the India-rubber tube, when the same alternate pumping and admission of carbonic acid are gone through for the removal of the nitric oxide as were before employed for abstracting the air. When this is accomplished the flask is separated from the rest of the apparatus (which is at the time filled with carbonic acid), and the first part of the process is at an end. The second part is an application of Professor Bunsen's method—namely, of converting the iodine into hydriodic acid, by means of an excess of a standard solution of sulphurous acid, and estimating the amount of excess of this latter by a standard solution of iodine. To save reference I will shortly mention the relative strength of these solutions and the method of using them.

The test solution of iodine is made by dissolving 25 grains of carefully purified iodine in 1 pint (7000 grs.) of distilled water. In using it a burette containing 700 grs. is employed, and this being divided into 100 parts, each part (or septem) contains ·025 (or $\frac{1}{40}$th) of a grain of iodine, and represents ·00356 grains of nitric acid. As it is easy by practice to read to one-half or even one-third of a measure, the estimation may be made to ·001 of nitric acid.

The sulphurous acid solution is of no absolute determinate strength, but is standarded every day or oftener when experiments are in progress. It is made by mixing 1 part by measure of a saturated solution of sulphurous acid with about 250 parts of water. A pipette containing 100 septems (700 grains) is used for measuring this standard sulphurous acid, and this quantity will generally require from 30 to 35 measures of the standard iodine solution for its neutralization.

The sulphurous acid solution is so weak that a portion thrown on to the palm of the hand will hardly be detected by the smell. To ascertain its standard value, a pipette-full diluted with water is placed in a pint flask, a few drops of solution of starch are added, and the iodine solution is dropped into the mixture till the blue colour becomes permanent; a single drop is enough to produce the change when the point has been arrived at. When the solution becomes weak, a little more of the strong sulphurous acid is added. It is conveniently kept in a large loosely corked bottle, furnished with a syphon tube, upon

which is an Indiarubber joint with a brass spring as in Mohr's burettes.

To ascertain by means of these solutions the quantity of iodine which has been liberated by the action of the nitric acid, the contents of the small flask are washed out carefully (and by the help of a little iodide of potassium to assist in the solution of the iodine) into a larger flask, the quantity of liquid being made up with distilled water to about 5000 or 6000 grs. A measured quantity of the sulphurous acid solution is now added by means of a pipette; if sufficient it entirely destroys the colour of the liquid. A few drops of solution of starch are now introduced, and the standard iodine liquid is added drop by drop, until the blue colour of the iodide of starch becomes permanent. A simple calculation founded upon the known relation of the two liquids, as before explained, gives the quantity of nitric acid in the pint of water operated upon in the analysis. If iodine has been liberated during the process, the sulphurous acid will require the addition of a smaller quantity for its destruction. Supposing the standard to be 30 measures of iodine liquid, and that in an experiment only 20 are required—then as each measure indicates ·00356, the ten measures *not required* will indicate ·0356 of nitric acid present in the water examined.

Iodide of potassium was originally employed in this process instead of iodide of silver. To this substance, however, there were found to exist two objections: the first of these was, that if the waters contained sulphates, which would be the case in nine out of ten, a separation of iodine occurred even in the entire absence of nitric acid. It is well known that the re-action upon which Bunsen's process is founded, is reversed when the solutions are strong; that is to say, iodide of potassium or hydriodic acid and sulphuric acid, unless very dilute, mutually decompose one another with formation of sulphurous acid and liberation of iodine.

In the trials which were made with iodide of potassium, the hydrochloric acid employed must have liberated sulphuric acid, which was then acted upon by the hydriodic acid formed at the same time.*

This objection to the use of iodide of potassium was indeed successfully removed by the employment of caustic baryta in the place of lime in the boiling down of the water under examination, as in this way sulphuric acid was removed from the liquid; but another difficulty still remained.

We found that a mixture of hydrochloric acid and iodide of

* This is an additional illustration of the law of Berthollet of the distribution of acids and bases, as it is clearly seen that hydrochloric acid can decompose a sulphate. There is no doubt that a very delicate process for sulphuric acid and sulphates might be founded on this circumstance.

potassium gave rise, upon lengthened boiling, to a liberation of iodine, slight indeed, but still sufficient to impair the delicacy of the results unless great attention was paid to the duration of the operation.

Iodide of silver is not subject to either of these objections; it is not affected by hydrochloric acid, neither is iodine liberated from it by sulphuric acid when sulphates are present.* Iodide of lead was tried, but with a less satisfactory result.

In the foregoing account I have supposed the water to be free from organic matter, which is, however, seldom the case. The presence of organic matter, by acting on the nitrate, would very greatly interfere, unless steps were taken to counteract it. For this purpose, in almost all cases, I have recourse to a solution of permanganate of potash; two or three drops of which are added to the water in the act of boiling it down. The permanganate effectually destroys the organic matter with the production of peroxide of manganese; it is added drop by drop, so long as the amethyst tint imparted by it is destroyed; when this, after some time, remains permanent in the boiling solution, it is known that the whole of the organic matter is oxidated. The excess of permanganate is removed by adding a few grains of carbonate of lead to the boiling solution, by which peroxide of manganese and puce oxide of lead are precipitated. When the latter is sufficiently concentrated, carbonic acid is passed into it as before mentioned; the liquid is filtered, and the evaporation is completed in the small globular flask. The complete dryness of the product, and the absence, as far as can be, of carbonates, are desirable on account of the necessity that the hydrochloric acid should be as strong as possible, in order to act on the last portions of nitrate.

I now proceed to give instances of the amount of accuracy which attends this process.

The following are seven determinations of nitric acid in nitrate of potash repeatedly crystallized. A weak solution of the nitrate was employed, and a given quantity of it carefully measured by a pipette, and evaporated to dryness. The quantity of nitrate employed was 1·084 grains, representing 0·585 grains of nitric acid. The results were—

	Nitric Acid.
1st Experiment	0·582
2nd "	0·585
3rd "	0·584
4th "	0·581
5th "	0·580
6th "	0·584
7th "	0·583

* In the instances given further on of the delicacy of this process for nitric acid, will be found one in which a sulphate was employed without altering the result.

In the last instance 10 grains of pure sulphate of lime were added with the iodide of silver, but without deranging the result. These results are not selected from a greater number, but were obtained in seven consecutive experiments. The mean of these results is as nearly as possible 0·583 (0·5827), as against 0·585, the quantity of nitric acid experimented upon, or an error of 1 in 291 on the whole quantity. The greatest deviation is less than 1 per cent.; that is to say, that for 100 parts of nitric acid the worst result would show 99.

If, as is very possible, the nitrate after all was not quite pure, and that the deviations were equal above and below the truth, they are then still further reduced.

I do not think it necessary to say a word in explanation of the delicacy of a method, which deals with quantities as a whole, which heretofore would have been exceeded by the differences of two experiments.

The following are duplicate analyses of different samples of drainage and rain waters given in the preceding paper—

Nitric Acid in Drainage Waters (Mr. Paine).

No.		In a pint.	No.		In a pint.
1.	1st determination	0·7209	5.	1st determination	0·342
	2nd "	0·7132		2nd "	0·347
	Mean "	0·7170		Mean "	0·345
2.	1st "	1·478	6.	1st "	0·807
	2nd "	1·470		2nd "	0·803
	Mean "	1·474		Mean "	0·805
3.	1st "	1·272	7.	1st "	1·149
	2nd "	1·290*		2nd "	1·142
	Mean "	1·281		Mean "	1·146
4.	1st "	0·192			
	2nd "	0·197			
	Mean "	0·195			

Mr. Acland's Samples.

No.		In a pint.	No.		In a pint.
2 A.	1st determination ..	0·0623	3 A.	1st determination ..	0·0480
	2nd "	0·0633		2nd "	0·0490
	Mean "	0·0628		Mean "	0·0485

Mr. Hoskyns' Samples.

No.		In a pint.	No.		In a pint.
1.	1st determination	0·464	3.	1st determination	0·441
	2nd "	0·461		2nd "	0·439
	Mean "	0·463		Mean "	0·440
2.	1st "	0·114	4.	1st "	0·117
	2nd "	0·107		2nd "	0·117
	Mean "	0·110		Mean "	0·117

* The discrepancy here seen was accounted for by an accident to the pump, which delayed the experiment.

The foregoing are probably sufficient illustrations of the accuracy of this process. They are fair instances of the actual results, and wherever greater deviations are found to occur, which is very seldom the case, the cause is generally discernible during the process of analysis, and may be avoided by due care.

It is only further necessary to remark, that the possible sources of error in this method have been carefully looked into. The most probable would be the production of nitric acid by the action of the permanganate of potash, either on ammonia or nitrogenous organic matter in the waters. I have satisfied myself, by direct experiments, that in neither case does such production of nitric acid occur.

Determination of Ammonia.

The accompanying woodcut will probably be understood without much explanation. Into the bottle *a*, which has a capacity of about 1 gallon (70,000 grains), a quart of the water to be examined is introduced, together with a small quantity of lime, and a quantity of recently fused common salt, the object of which last will be immediately explained. This vessel is connected with the bottle *d* by glass tubes *c* of about $\frac{5}{8}$ of an inch external diameter.

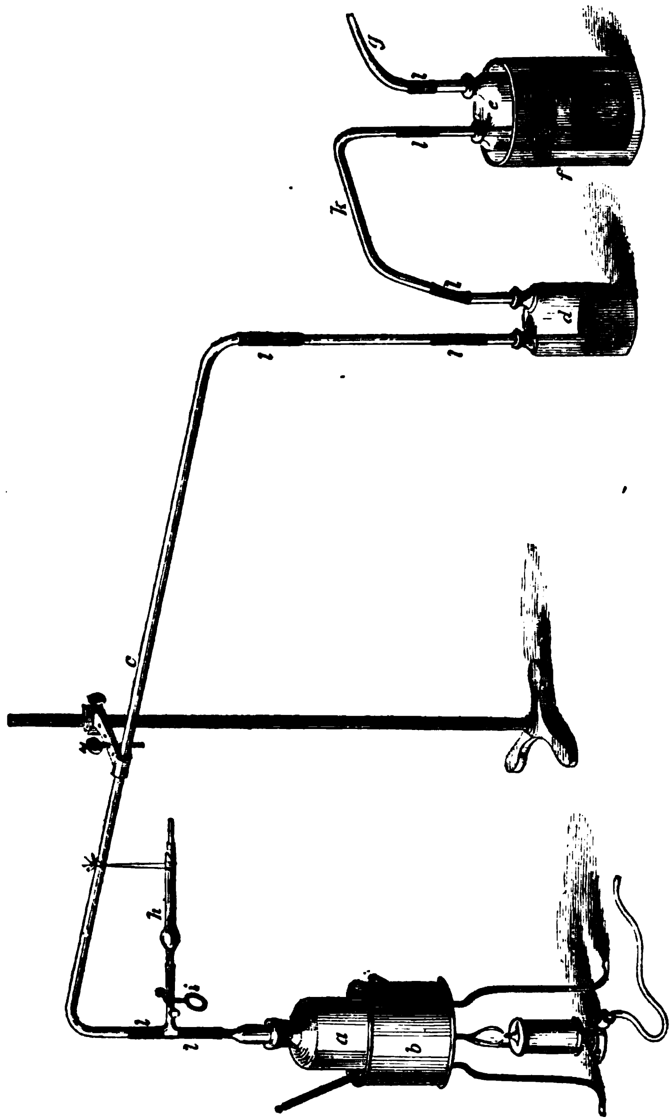
The vessel *d* is a bottle with two necks, into which the glass tubes are ground; into this vessel is introduced a solution of bisulphate of potash, for the purpose of collecting the ammonia brought over by distillation from the liquid in *a*.

The tube *c* connecting these vessels cannot obviously form a stopper, and at the same time continue of any length into the bottle *d*, but a smaller tube is by means of an India-rubber joint connected with it, so as to dip into the liquid in the vessel *d*. The same is true of the tube *k*, which connects *d* with *e*, but which stops short at about two-thirds of its depth.

The vessel *e* is surrounded by cold water in an outer vessel *f*.

At *g* the apparatus is connected with the pump at the point *h* in the nitric acid apparatus. As these two operations have, in the case of waters, to be carried on at the same time, it is convenient to have the respective apparatus attached to the same pump.

Such being the arrangement, heat is applied to the water bath *b*, and a vacuum is created throughout the apparatus by the pump. When the liquid in *a* commences to boil, a trifling condensation at first occurs in the tube *c* and the vessel *d*, but these soon come to have a temperature equal or nearly equal to the liquid in *a*, and from that time the bubbles of vapour pass through the liquid in *d*, just as would a fixed gas, and are finally condensed in *e*, so



Estimation of Ammonia (Way).

that no considerable amount of condensation occurs in the pump to impair its action.

In this way we are enabled as it were to *wash* all the vapour, causing it to leave behind it any ammonia which it may contain, without greatly increasing the bulk of the liquid to be subsequently tested. The operation proceeds regularly and without requiring much care or attention, except in the occasional improvement of the vacuum as a slight leakage may occur. We may in this way, if we please, distil over the greater part of the water operated upon.

The object of adding the salt to the liquid to be distilled is to elevate the point of vaporization of the water, whilst at the same time that of the ammonia is diminished from the well-known circumstance that a liquid saturated with a salt has its power of dissolving gases almost destroyed. We have found that under these circumstances all the ammonia present is brought over with one-fifth, and indeed in some instances with one-tenth, of the water; but it is preferable to distil a larger quantity. Bisulphate of potash is substituted for sulphuric acid as a means of collecting the ammonia, as it may well be supposed to be less volatile than the latter. The resulting liquid is tested with a standard solution of ammonia, of such a strength that each septem (7 grains) represents ·02714 grains of ammonia. A neutral solution of litmus is employed, as is usual in such experiments. It is proper to state that when this apparatus was used in the way described an apparent excess of ammonia was frequently obtained, due, there can be no doubt, to a mechanical carrying over of small quantities of the acid liquid in *d* by the bubbles of vapour. I believe that with care such a result may be avoided.* The results actually given were obtained by a modification of the method of using the apparatus. The vessel *d* was kept cold by means of an outer vessel of cold water, and the greater part or the whole of the distilled liquid condensed there, and was tested at one operation. Even in this form the use of a vacuous apparatus is most desirable, as the process is so regular and so much under control, whilst it is perfectly impossible to suffer loss by escape of ammonia. Numerous direct experiments have been made to prove the correctness of this process, but it may be sufficient to give a few instances of duplicate analyses where the quantities distilled over and other conditions have been unlike, and the similarity of result cannot therefore be due to accident. The following are such analyses of the rain-water of five different months in the year 1855, as mentioned in the foregoing table.

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* A plug of asbestos was inserted in the tube at *k*, but failed to prevent the acid liquid from being carried over.

The results are given on the gallon: as, however, only one quart was operated upon, the actual errors are only one-fourth of what they here seem:—

		Ammonia, per gallon.			Ammonia, per gallon.
August	1st experiment	·0800	November	1st experiment	·0540
	2nd "	·0814		2nd "	·0542
	Mean "	·0807		Mean "	·0541
September	1st "	·0950	December	1st "	·0670
	2nd "	·0949		2nd "	·0678
	Mean "	·09495		Mean "	·0674
October	1st "	·0610			
	2nd "	·0610			
	Mean "	·0610			

The deviations in any two of these analyses are not greater than those which are inseparable from the best methods of alkalimetry, and it may well happen that no part of the difference results from the distillation. In the case of December, for instance, in which the largest error is seen to occur, the actual difference between the two determinations on a quart of water is only ·0002 of a grain of ammonia—a quantity which is represented by a quarter of a measure of the test liquid. Now, as this quantity is little more than one drop, and as it is made as weak as is consistent with the power of the eye to observe the change of colour, it is obvious that we cannot expect to attain any greater amount of accuracy. These duplicate analyses are all I can find in my books as made upon waters; they are, consequently, in no way selected for the purpose: they were, moreover, made by different experimenters.

15, *Welbeck-street, Cavendish-square.*

VI.—*On the Natural History of British Meadow and Pasture Grasses.* By JAMES BUCKMAN, F.G.S., F.L.S., Professor of Geology and Botany in the Royal Agricultural College.

INTRODUCTION.

In giving descriptions of grasses, it may be well to set out with the acknowledgment that these plants form an exceedingly natural group, which at once supposes that, although they have such differences that species can be recognised by careful analysis, they have yet such agreement in common that the most casual observation is usually sufficient to determine one of the family to be a 'grass,' or at least to enable us to refer it to the *Graminaceæ*, as the natural order of plants to which it belongs.

Here, then, we see that there must be a great similarity of parts in species of grasses, and, as these parts are often minute, it

follows that in order to understand descriptions so as to enable us to distinguish one species from another, or to *analyse* them, great care must first be taken to master the minute distinctive characters which such parts may present. This done, the student of grasses may soon know them tolerably well, whereas, if neglected, he may attain to the knowledge of *names*, but it will only be in a traditionary manner, and therefore with a constant liability to error, according as his informer is well or ill acquainted with his subject.

This paper is intended to illustrate the following subjects:—

1st. An account of the structure of grasses; and

2nd. To offer a system of classification or arrangement dependent thereupon.*

1. *Structure of Grasses.*—In grasses we meet with the following parts, all of which, though tolerably constant in form in individuals of each species, yet in their variations *in species* make up the sum of those distinctive characters which enable the botanist to separate one species from another. Such are—

The Root, or descending axis, consisting of root fibres and rhizome.

Culm, or ascending axis, consisting of stem, with its nodes and joints.

Leaves, the appendages of the axis, consisting of sheath, ligule, lamina.

Flowers, or *reproductive organs*, consisting of floral envelopes, stamens, and pistils.

Seeds, or *Fruit*, consisting of grains of various forms and sizes.

The roots of grasses usually consist of small fibres, which, in starting from the seed, burst through the radicle, or seed-root, like the inner valve of a telescope from the outer; this, which is called by botanists *Endorhizal*, from two Greek words signifying *within a sheath*, may be well observed in the germination of such large grasses as are presented in the cereals, as wheat, barley, &c. Roots are sometimes hard and wiry, especially in such species as grow in damp and boggy places; whilst in others they are exceedingly flexile, the main roots often creeping great distances in search of food, and then branching off into innumerable *fibrils*, or *rootlets*, the ends of which, consisting of the newest cells or growth, form the *spongioles*, or suckers, by which nutriment is taken from the soil into the plant system. It is hence necessary, in the cultivation of grasses, that the soil for the reception of the seed should be of good *tilth*, and especially that its mechanical consistency should be such as that it will not greatly

* The description of Species, with an account of their qualities, will follow in our next Number.

expand in moisture, and so push the plants out of place,—or crack in drought, in which case the rootlets, or active parts in life and increase, are broken away just at the period when they are most required. Roots are without buds, from which it will be seen that all the parts of a grass which grow beneath the surface are not always true roots, such, for instance, as the runners in the common couch (*Triticum repens*). These receive the name of *Rhizome*, or underground stems, and it is by means of these that the couch tribe of grasses so quickly spread from a common and small centre into large patches; as, though they creep for a considerable distance, yet their points ultimately rise to the surface and then expand new leaves, and, in fact, form distinct and perfect individuals, which, if separated from the parent, all the more rapidly give rise to independent colonies, and indeed these scions do as their parent did before them.

Several species of grasses have this tendency, and consequently when it occurs it forms a good distinctive character. Hence though the *Triticum repens* has a rhizome, the *T. caninum* is only furnished with a fibrous root; some of the *Poas*, as *Poa pratensis* and *P. compressa*, have rhizomes, whilst *Poa annua* and *P. trivialis* are without any tendency to a creeping habit of growth.

Agriculturally it is necessary to distinguish the different forms of couch, as the species of one district may be absent from another; and as even the rhizome will vary in being large or small, so will its eradication much depend upon its difference in form and habit. However, we shall hereafter see that several species of grass become useful from this very structure in keeping together banks of sea-coast, canals, and the like; and it is a matter worthy of serious consideration and careful experiment whether they could not be made available in consolidating the slopes of railway cuttings, which give so much trouble and cause such constant yearly outlay on some lines.

Culm—Stem (B).—The stems of grasses are usually hollow (*fistular*), to which, however, the *Molinia cærulea* (purple molinia) of wet places offers an exception in its solid stem. It is rounded, except in *Poa compressa* (flat-stemmed meadow-grass), in which the trivial name has been given from the oval form on a transverse section, as though it had been subject to compression.

The stem is separated into long or short lengths, called *joints*, by the intervention of *nodes* (C) (knots), which are solid and tend much to strengthen the structure of the plant, to which end they will be found to be closer at the base, where the strain would be greatest on account of these light plants swaying forwards and backwards in the wind, and more remote upwards in the culm, from which are suspended the newer and more active leaves.

Stems may vary in being quite *smooth*, *ribbed*, armed with hairs

—which may be long or short—*bristly* or *downy*, in proportion as this kind of *armature* may be *coarse* or *harsh*, or *fine* and *soft*.

The nodes again may be of a different colour from the culm, or, like it, may be smooth or armed in a similar manner.

The leaves (D) consist of the following parts:—

D. The sheath, = *petiole*, or leaf-stalk of other plants.

D'. The ligule, or tongue.

D''. The lamina, = blade, or flat part of the leaf.

The sheath is the footstalk of the leaf. This takes its rise from the nodes, one from each, arranged on alternate sides of the culm. The whole length of the sheath, which is variable, is folded around the culm, from which it can be loosened by unwinding without fracture, a circumstance which serves to distinguish the grasses from the sedges (*Carex*), as the sheath of the latter is a continuous tube, in which the solid and often triangular culm is *inserted*, not folded. This is a distinctive character of great importance to observe, inasmuch as grasses and sedges are outwardly much alike—indeed some species of the latter are called *Carnation Grass*—but greatly different in quality; grasses being for the most part highly nutritious plants, whilst sedges are not only usually innutritious, but, from the harshness of their herbage, are often a source of injury and annoyance to the creatures that from starvation are sometimes doomed to eat of them.

The blade—lamina—D''', is the expanded part of the leaf. It is sometimes large and drooping, as in the larger or flag-like grasses, but occasionally it is very minute, especially when compared with the sheath, as in the *Avena pubescens* (soft oat-grass). In some species the blade is long and the sheath short. The blade is traversed by longitudinal parallel lines, which are called the *leaf-veins* or *nervures*: these may be *broad*, *narrow*, *rigid*, *soft*, *armed with rough hairs*, and so on, all of which are not only points of distinction in species, but aid in making up the sum of those differences which will ever be found in good and bad pasture grasses: as, for instance, grasses in which the herbage is covered with long downy hairs are mostly poor and innutritious in quality; on the other hand those of a harsh and rigid structure, with serrated leaves, whose edges act as a saw and whose flat blades perform the office of a file, even if nutritious, would nevertheless be refused by cattle on account of their mechanical inconvenience.

The ligule, D''.—At the point where the sheath ends and the blade begins occurs a thin and usually white semi-transparent membrane, termed the *ligule*, or tongue. This, as it varies so much in size and form, will be frequently referred to in diagnosis by some such terms as the following:—

Short, in *Poa pratensis*, smooth-stalked meadow-grass.

Pointed, in *Poa trivialis*, rough-stalked ditto.

Notched, in *Bromus mollis*, soft brome or lop grass.

In pairs, in *Ammophila arundinacea*, common sea-reed.

Its value as a distinctive character may be drawn from an examination of *Poa pratensis* and *P. trivialis*, as it assists at a glance to distinguish two grasses, much alike in appearance, though very distinct in habit and general properties.

The use which this part of the leaf subserves would appear to be that of more securely fastening the upper part of the sheath to the culm, as without it the wind would tear the leaves downwards, in which case their functions would become much disturbed, and they would soon wither and die. The flower in grasses consists of the elements of an entire plant, each bunch or *locusta* of flowers being but a grass in miniature, consisting of a central axis or stem with its alternately arranged leaves, the stamens, pistils, and seeds in the axils of which are but buds; this fact may at once be seen in *viviparous* specimens, such as are often found in the *Lolium perenne* (perennial rye-grass) and *Cynosurus cristatus* (crested dog's-tail), in which, instead of flowers, we have complete buds, which we have indeed detached and grown as distinct plants of their respective species.

Now, in these examples the case is very different from that of germination in the ear which takes place in laid and damp wheat, as in the latter the seeds have been perfected, and germination takes place from heat and moisture in the usual manner; but in *viviparous growth* the envelopes and their organs, instead of growing seeds on the principle of arrested development, go on growing into branches, and no seed is consequently perfected.

Flowers consist of the following parts:—

Glume =outer chaff-scales *Glumel* =inner chaff-scales	} Floral envelopes.
Stamens Pistils	} Fertilizing organs.
Seeds = grain=reproductive organs.	

Floral envelopes, upon the theory just enunciated, consist of metamorphosed leaves; they are arranged in pairs, and *each* scale starts from an opposite side of the central axis, but not from the same point. The outer pair subserves the same use as the *calyx* in other plants, and receives the name of calyx, *glume* (E); the inner pair, or pairs—for sometimes several occur in a single glume—is termed *glumel*, and the pieces of which either are formed obtain the name of valves, the lower one being the outer and the upper one the inner of each respectively.

The glumes differ in shape, and in the presence or absence of longitudinal lines or *ribs;* it may be large enough to *include* or conceal the *glumel*, or it may be considerably smaller than the

latter. Again, the outer and inner valve may vary in size and shape, and, indeed, present many differences which will be explained in simple language in the descriptions of species.

The glumel (F), *corolla*, is subject to like differences in form and proportion, facts which can only be well explained with a specimen in one's hand; and it should not be forgotten that in grasses we have to deal with plants which, though simple in their structure, present such minute differences that the eye must become by use accustomed to examine and trace them, and as so many characters are necessarily derived from such important organs as the flowers, which are often small, even a poçket lens will frequently be required to assist the ordinary vision.*

The glumel is often found to be armed by a projecting spine or beard; this is of greater or less length, and is termed the *awn*,† and may be well observed in bearded wheat and in both wild and cultivated barleys. This organ, when long and stiff, and armed as it is sometimes with projecting *spiculæ*, renders grasses where they occur exceedingly objectionable, especially for hay, though the grass may be good if kept from flowering by constant depasturing; such are the species of *Hordeum* (wild barley).

The fertilizing organs consist of the stamens (H) which possess the following parts:—

a. The filament (H′), or thread which supports
b. The anther (H″), or case in which is secreted
c. The pollen, or fecundating dust.

The filament, by reason of its length, may cause the anther to be *exserted* or standing out from the flower, or from its shortness to be *inserted* or included in its valves, the anther may be varied in its colour as follows:—‡

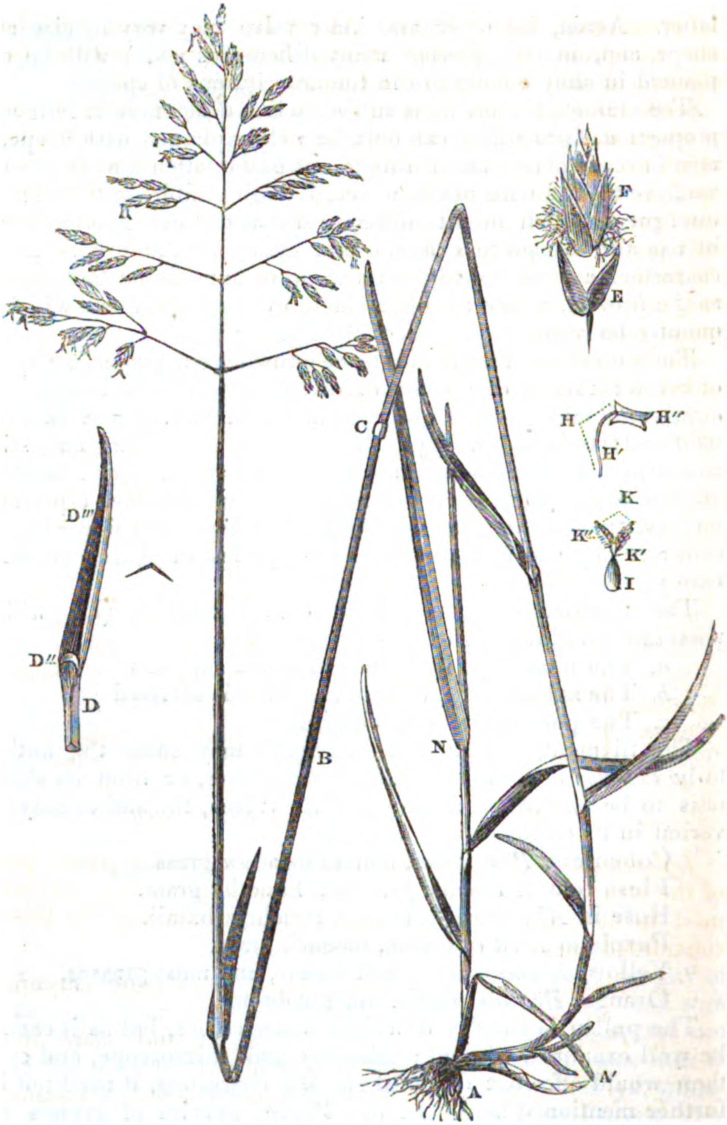
Colourless, *Poa annua*, annual meadow-grass.
Flesh colour, *Phleum pratense*, Timothy grass.
Rose in *Alopecurus pratensis*, meadow foxtail.
Purple in *Aira cæspitosa*, hassock grass.
Yellow, *Bromus mollis*, soft brome, and most grasses.
Orange, *Bromus erectus*, upright brome.

The pollen is usually of a light straw colour, but as it cannot be well examined without a tolerably good microscope, and even then would offer but doubtful specific characters, it need not be further mentioned here. In our British species of grasses we

* For this purpose a lens of ordinary power will suffice, such as may be purchased at the optician's for about 9*d*.

† The awn, when present, may represent the blade of a leaf, whilst the glume and glumel are the representatives of the sheath.

‡ The colour varies much in the same species, some being more liable to variation than others.



Poa pratensis.

find three stamens, with but very few exceptions, to each floret, and hence grasses belong to the Linnæan class *Triandria*.

The *Pistil* (K) consists of a style, which is in one or as it were split into two parts, each surmounted by a *stigma* (K′) either pointed or feathery; they are mostly very pale in colour,

but occasionally highly tinted. As our British grasses, with but one exception in *Nardus stricta*, heath grass, possess two *stigmata*, so they belong to the Linnæan order *Digynia*.

Seeds are sometimes loose in the chaff-scales, as in the wheat; in others the glumel is adherent, as in barley;—a circumstance which may explain how readily wheat grain is shed when 'dead ripe,' as the attachment of the seeds to the chaff-scales is much less firm than that of the flower to the flower-stalk: these facts fully justify the process of reaping, as involving more care, for the former, and of the rougher method of mowing for the latter; this, however, is now calculated as a matter of expense, and not one of mere waste.

For the sake of perspicuity the following resumé of parts is added, with references to our figure:—

	Root	Fibres, A.	The true root fibres.
		Rhizome	Creeping underground stem.
	Stem	Culm, B.	The whole aboveground stem.
		Joint	A single length from node to node.
		Node, C.	The hard knot between joints.
	Leaf	Sheath, D'.	The folding portion of a leaf.
		Ligule, D''.	The tongue of the leaf.
		Blade, D'''.	The lamina, or free part of leaf.
	Floral Envelopes	Glumes, E.	The outer chaff-scales, in pairs.
		Glumels, F.	The inner chaff-scales, ditto.
Fertilizing organs.	Stamen	Filament, H'.	The thread supporting the anther.
		Anther, H''.	The pouch containing the pollen.
		Pollen	The fertilizing dust.
	Pistil	Style, K'.	The support of the stigma.
		Stigma, K''.	The receptacle for the pollen.
		Seeds, I.	The reproductive organ.
		N. A barren shoot	A flowerless branch.

Inflorescence.—Thus far we have described the separate parts of the structure of grasses; we have now to point out the terms used to designate these in aggregation, which will be briefly considered under the following heads:—

a. Herbage, that is the leaf portion, principally concerned in pasture.

b. Culms, or parts which grow upright, and make up so much of the bulk and weight of hay.

c. Heads of flowers, the various forms which they assume.

a. The quality of grasses depends so much upon the quantity and physical character of the herbage, that for agricultural purposes these should always be noted with great care; hence, if for hay, both bulk and quality is much influenced by luxuriant leafage, a character in which grasses will be found to differ in a remarkable degree; if however this be rough and unpalatable,

that is, the 'sour grass' of the farmer, no matter how great its quantity, such should be discouraged. Again, if for depasturing, it will be necessary to note such facts as *longevity*, and how the species succeeds in sending up herbage under continual mutilation by feeding off.

Most grass meadows are sometimes mown for hay and then depastured in the shape of *aftermath*, whilst in some years no hay crop is taken, so that it is necessary to encourage the growth of all such species as will be found adapted to our soil, and will there yield us the best return in both hay and herbage. Connected with this part of the subject we must not omit *duration;* as for permanent pasture *perennial grasses* are absolutely necessary, annual species having nothing to recommend them.

b. The *Culms* of grasses, whether *hard* and *wiry*, or soft and pliable, *bitter* or *saccharine*, *scanty* or *abundant*, should also receive attention, as hay, both in quality and bulk, will much depend upon these circumstances.

c. Heads of flowers.—These are aggregated from single *locustæ*, spikelets, or smaller bunches or bundles of flowers which may vary in the following manner:—

a. A single glumel to each pair of glume-valves.
b. Two glumels and sets of flowers to a pair of glumes.
c. Three or more glumels to each pair of glume-valves.

Each flower, or *locusta* of flowers, as *b* and *c* would be termed, may be attached to the stem in various ways:

a. On short upright footstalks (pedicels), in which the flowers unite into a compact head, called a *spike*—example, Foxtail grasses.

b. On longer upright footstalks (pedicels) forming an upright panicle, as in Bromus mollis, soft brome.

c. On long and flexile footstalks (pedicels) a drooping panicle, as *Bromus asper*, rough-stalked brome.

2. *Classification.*—In a large group of plants, like the grasses, their study necessitates their arrangement into smaller groups or bundles in order to facilitate their analysis, to which end various characters, more or less minute, have been dwelt upon by different authors. We here choose the method of arrangement that appears to us as the most simple, making use of the foregoing descriptions and terminology as our guide.

A.—Stamens, 2. Styles, 2.

1. *Anthoxanthum*—panicle spicate.
2. *Hierochloe*—panicle lax.

B.—Stamens, 3. Style, 1.

3. Nardus—spike unilateral.

C.—Stamens, 3. Styles, 2.

* *Spikelets single flowered.*
† *Flowers spiked.*

4. *Leersia*—glumes absent.
5. *Alopecurus*—spicate, glumes connected at the base, spike compact.
6. *Phleum*—spicate, glumes distinct, spike compact.
7. Ammophila—spicate, glumes pointed, with a tuft of hairs at the base, spike compact.
8. *Lagurus*—spicate, glumes with long bristly points, spike short and compact.
9. *Phalaris*—spicate, glumes broad, glistening seeds, smooth, spike less compact.
10. *Gastridium*—spicate, glumes swelling at the base, spike less compact.
11. *Polypogon*—spicate, outer glume awned, spike less compact.

†† Flowers paniculate, more or less lax.

12. *Milium*—panicle spreading, glumes herbaceous.
13. *Stipa*—panicle erect, glumes coming out to a fine point, inner glumel with an awn ten times the length of the flower.
14. *Calamagrostis*—panicle loose, glumes surrounded by silky hairs.
15. *Agrostis*—panicle loose, glumes lancet-shaped, nearly equal.

††† Flowers spicate, arranged on two sides.

16. Rottbolia—spikelets alternate, glumes equal.

†††† Spikelets arranged unilaterally.

17. *Spartina*—spikelets unilateral, glumes unequal.
18. *Cynodon*—spikelets in alternate pairs on one side, glumes very unequal.
19. *Digitaria*—spikes branched, spikelets alternate on one side, glumes very unequal.

** Spikelets with one or two perfect florets, sometimes with one or additional florets, which are imperfect.

†† Fertile flowers, one; imperfect flowers, one or two.

20. *Setaria*—panicle spicate, flowers surrounded by bristles.
21. *Panicum*—panicle spicate, spike-branched glumels, with short hairs.
22. *Molinia*—panicle contracted but not spicate, glumes acute.
23. *Melica*—panicle lax, glumes rounded.
24. *Catabrosa*—panicle spreading, glumes obtuse.
25. *Aira*—panicle spreading, glumes unequal in size.
26. *Triodia*—panicle of few *locustæ*, which are large and tumid.
27. *Holcus*—panicle lax, florets soft, with downy hairs.
28. *Arrhenatherum*—panicle lax, glumes and glumels with bifid or notched points.
29. *Sesleria*—panicle spicate, glumes with trifid, glumels with bifid points.
30. *Cynosurus*—panicle spicate, flowers hidden in a comb-like shield, *involucre* of botanists.

*** Spikelets (*locustæ*), with three or more perfect flowers.

† Spikelets forming bilateral spikes.

31. *Elymus*—spikelets (*l.*) in twos or threes, both valves of the glume on one side of the spikelet.
32. *Hordeum*—spikelets (*l.*) in threes, of which only the central one is perfect.
33. *Triticum*—spikelets (*l.*) alternate on the *central axis* (*rachis*), glumes transverse to it.
34. *Brachypodium*—spikelets (*l.*) alternate on the central axis (*rachis*), glumes transverse to it.

35. *Lolium*—spikelets (*l.*) alternate, not transverse, each with a single glume.

†† Flowers paniculate, panicle more or less *lax.*

37. *Poa*—panicle lax, glumes unequal valves, the inner glumel notched at the extremity.
38. *Briza*—panicle lax, glumes equal, tumid.
39. *Dactylis*—panicle somewhat compact, glumes pointed, glumels awnless.
40. *Festuca*—panicle lax, glumes finely pointed, glumel with a short awn.
41. *Bromus*—panicle lax, glumes more or less rounded, outer glumel with a long awn, inner one edged with fine hairs.
42. *Avena*—panicle more or less lax, glumes thin, transparent membrane, glumels adherent to the seed.
43. *Phragmites*—panicle more or less compact, glumes and glumels finely pointed, the latter very unequal.

Now, in the foregoing Table, we have arranged 43 genera, which will be found to include about 125 species. Of these however only about 20 genera, containing not more than 40 species, will be found to possess any particular interest in an agricultural point of view; only these therefore will be fully described in our forthcoming paper, and their properties and capabilities pointed out, whilst sufficient reference will be made to the remaining species to enable the student to refer them to their proper places.

Cirencester, March, 1856.

VII.—*On the Roots of the Wheat Plant.* By JAMES BUCKMAN, F.G.S., F.L.S., Professor of Geology and Botany in the Royal Agricultural College.

PRIZE ESSAY.

WHEAT and all our cereals belong to that division of the endogenous or monocotyledonous class, which, from their *glumes* or chaff scales, have received the name of *glumales.* This class is distinguished by *endogenous* stems, non-separable bark, parallel-veined leaves, and an ovary of a single cotyledon.

The natural order includes the carex or sedge family (*cyperaceæ*) ; but the grass family (*graminaceæ*) is distinguished as follows:—

1. *Graminaceæ.*—Evergreen herbs, with cylindrical and usually fistular stems closed at the joints. The stems are covered with a coat of silex and are sometimes solid. Leaves narrow, undivided, with a split sheath, and a membranous expansion (*ligule*) starting alternately from the joints (*nodes*).

2. *Cyperaceæ.*—Grasslike herbs, with solid stems, seldom with partitions at their nodes, frequently angular. Leaves narrow, undivided, and when wrapping round the stem it is with a tubular and not a split sheath.

The corn or cereal grasses are cultivated for their seeds, which consist of the following parts:—the *perisperm* (diagram 1 *a*), which supports *b*, the *embryo*, with its *radicle*, *c*, from which in germination proceed the roots; and *d*, a *plumule* or bud, which forms the ascending axis to support the leaves, and ultimately flowers and fruits or seeds. These parts are included in an integument of two membranes (*e*), which, after grinding, in wheat, is left as the bran.

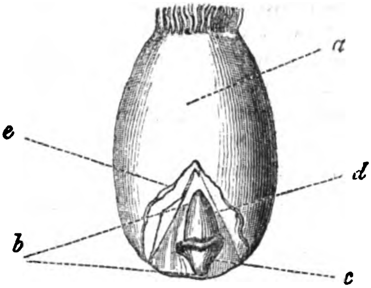


Diagram 1.—Grain of Wheat $\frac{8}{1}$.

Now, in a perfectly well-formed grain of wheat, the exterior will be plump and rounded, the integuments unbroken and not shrivelled. But grain of all kinds is liable to be poor and thin, and so capable of yielding but little feculent matter, a principle upon which its feeding properties and commercial value mainly depend. And it is also subject to many forms of disease, one of which, *ergot*, results in a most exaggerated form of the grain, and converts what would otherwise be nutritious constituents into matter that is said to act as a virulent poison.

Amongst all the cereals, wheat takes the highest rank, a position to which it is entitled from the quantity and agreeable nature of the nutritive seeds, as also from the strength of constitution of the plant, being suited to almost every climate, and cultivated in most degrees of latitude from the torrid to the frigid zone.

This general adaptability to different climatal circumstances is not, as might at first be supposed, due to a long list of distinct species, as it is doubtful whether all wheats ought not to be comprehended under one specific form; but its very liability to change of form and habit, that is, its facility of making *varieties* under different methods of cultivation, such as sowing in *autumn* or *spring*. Its distinctive constitution, such as *hardy* and *delicate*, derived from the difference in climate of its accustomed place of growth, and, indeed, even the varied proportionals of the chemical constituents of different forms, are all so many changes, induced by the action of external circumstances upon a species of plant highly susceptible of such influences, with, at the same time, a wonderful facility of preserving the identity of each form where such conditions are constant.

It was for some time considered that wheat belonged to the genus *triticum*, perhaps from the form of its spike of flowers and the peculiar flavour of its herbage: this latter fact, which be-

comes apparent upon crushing the leaves of a young wheat plant or leaves of the couch—*triticum repens*—in a peculiar disagreeable odour, is, doubtless, derivable from the presence of an essential oil, to which we may perhaps attribute the medicinal properties which cause the emetic action on dogs; and this unison of quality in the herbage of wheat and the wild triticums would at least lead to the inference of the affinity of the plants producing it.

Wheat has of late been decided upon as belonging to the genus *Ægilops*, perhaps all our forms having been produced from the *Ægilops ovata*. Upon this subject a beautifully illustrated paper will be found in the Royal Agricultural Society's Journal, with a detailed account of the experiments by which the changes from the wild grass to the cultivated wheat were produced by M. Fabre.

There can now, therefore, be no doubt as to the origin of our cultivated cereal, and as the author of this Essay has the ægilops in cultivation he would add that he sees no difficulty in receiving M. Fabre's conclusions.

These prefatory remarks have been made as concise as possible consistently with tracing the botanical position and origin of wheat. I shall, therefore, now proceed with more particular details in an essay on the development of the roots of wheat in cultivation, adopting the following divisions, as proposed by the Royal Agricultural Society, in the consideration of the subject.

1st. Characteristics of roots of autumn and spring sown wheats.

2nd. Acclimatization.

3rd. Development to what extent affected by top-dressings at various periods of growth.

4th. Lifting action of frost, commonly called throwing out.

1. *Characteristics of Roots, &c.*—In describing this subject it will be well to point out the facts connected with seed-sowing and its progress in the following order:—

a. The preparation of the seed.

b. The processes connected with germination.

c. The after development of winter and spring wheat.

a. There is no plant more liable to attacks from *epiphytes*, commonly called blights, than wheat, and experience has taught the farmer that various chemicals—such as the *caustic alkalis*, salts of copper, iron, and arsenic—if used as a pickle to the seed previous to sowing, prevents blight; and this is attempted to be explained upon the assumption that these matters kill the sporules of the fungi, but my own experiments upon this subject, together with careful investigation, seem to warrant the conclu-

sion that the beneficial action of these substances depends upon their destroying the germinating power of malformed and diseased seeds.

About three years since I planted four plots of wheat in the following order:—

1.	2.
Much diseased wheat, without pickle.	Much diseased, treated with sulphate of copper.
3.	4.
Perfect picked seed, without pickle.	Perfect picked seed, with sulphate of copper.

The results of these experiments were as under:—

Plot 1. Much of the seed germinated, but the crop was much blighted, both in straw and grain: in fact, scarcely a perfect ear of the latter.

Plot 2. A very small quantity of the seed germinated, the few resulting ears were free from blight.

Plot 3. Germinated, with a good and clean resulting crop.

Plot 4. The same result as Plot 3.

These experiments show that the pickling of wheat destroys the seed so as to prevent germination when the seed is diseased or ill-formed; but if perfect seed were always employed, no pickling is at all necessary, it being perfectly true that a diseased progeny must result from an imperfect stock in plants no less than in animals.

In committing the seed to the ground, theory confirms the practical propriety of sowing neither too shallow nor too deep, as the former renders it exceedingly liable to be eaten by birds; and if so shallow as to be exposed to light and air, the chemical changes attendant upon germination are not so carried on as to ensure the best results. If, again, it be sown too deep, though the first evil be avoided, yet germination beyond a certain depth is next to impossible, and if brought about the following evil is sure to result, namely, the re-rooting takes place at the upper joints, and the lower parts of the original stem and roots die away, thus causing a great loss in the vitality of a plant so cir-

circumstanced, as may be seen in the annexed diagram, where the rooting process is just commencing.

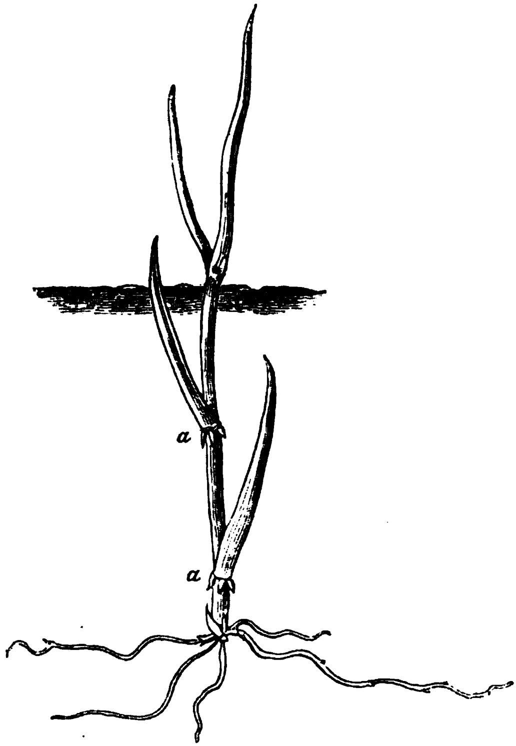


Diagram 2 (two-thirds of the actual size).—Blade of wheat rooting badly from deep sowing. *a a*, joint roots.

This evil, however, rectifies itself to a considerable extent in winter sown wheat, but in spring wheat deep sowing always irretrievably weakens the crop, as there is not time to remedy the evil in the way pointed out.

Upon this subject the following experiments by Petri may not be inaptly quoted:—

Seed sown to the depth of	Came above ground in	Number of plants that came up.
½ inch	11 days	⅞ths.
1 „	12 „	All.
2 „	18 „	⅞ths.
3 „	20 „	6/8ths.
4 „	21 „	4/8ths.
5 „	22 „	⅜ths.
6 „	23 „	⅛th.

This table demonstrates what I have found in my own experiments in wheat planting—that from 1 to 2 inches is the best depth; beyond this the plant becomes liable to joint-rooting, and besides losing much time in coming up they become thin and attenuated and do not *stool* or *tiller*, or if so this process is weak and irregular, inasmuch as the lateral buds proceed from the axils of the leaves, as in diagram 2 *a a*; and if one bud succeed another from below upwards, decay of some buds and irregularity in the growth of others is the result; if only the upper bud succeeds, which is the general case, much time is lost in the rectification of the plant by the decay of its lower parts.

b. The seed having been sown as evenly as possible at the required depth the following changes take place. The grain begins to obtain moisture from the soil, and consequently enlarges in size: in a few days the embryo shows a great change, in that it has become enlarged both above and below, the lower part soon protruding as a rootlet, the upper as a bud, quickly to develope leaves. Coincident with this proceed the chemical changes in the cotyledon, from which the germ is supplied with its food until the roots on the one hand, and the leaves on the other, become capable of acting, the one as purveyors, and the other as eliminators of that food with which the plant may be surrounded in the soil and the atmosphere, and upon which depends its after welfare.

If wholesome plant-food be in the soil, it progresses favourably; if the reverse, disease or death will be the result. If the supply of these be insufficient, the produce is small; if too great, we get blighted leaves and straw, with too small a proportional of corn. If bad seed be sown, we have a diseased and malformed plant, resulting in thin, diseased, and consequently blighted grain. All this, however, depends upon the air the plants get to breathe; if full of noxious vapours, they die; a small quantity of such gases as sulphuretted hydrogen, sulphurous acid gas, and muriatic acid gas, acting as a poison, and thus preventing wheat from being grown in the neighbourhood of some chemical and manufacturing works.

c. We now enter upon a more minute description of the subsequent changes that take place in the growth of wheat roots. After the *radicle a*, diagram 3, has burst through the integument lateral *rootlets* begin to develope themselves to its right and left, which, in their young state, are but sheaths from which protrude the true roots *b*, this method of growth being distinguished by the botanist as *endorrhizal*, from the Greek word ενδον, within, and is a characteristic of endogenous plants, especially of the grasses. These roots elongate for a greater or less length without branching, when slight projections mani-

fest themselves, through which shoot branches (*fibres*), which themselves go through the same process of branching, giving rise to (*fibrils*), a process which will be the better understood by examining the following diagrams.

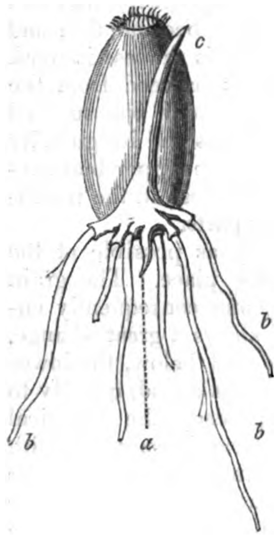


Diagram 3.—Germinating Wheat.
a. Radicle. b, b, b. Rootlets.
c. Plumule.

Now during winter this root development is fast or slow, according as the weather is open or mild, and cold and frosty. In cold weather it is nearly quiescent; a few mild days, however, result in one or more fresh rootlets budding from near the base of the old ones, coincident with which a bud starts from the axil of the first leaf.

If the plant be hardy, each of its early leaves may develope a like bud, when new roots will also start for their nutrition, until we have the initiative of several heads of wheat from a single seed. (Diagram 5, figs. 1, 2, *a*, *a*.)

Thus we have in the early growth of wheat the two organs, roots and leaves, keeping pace with each other in their development, new buds always

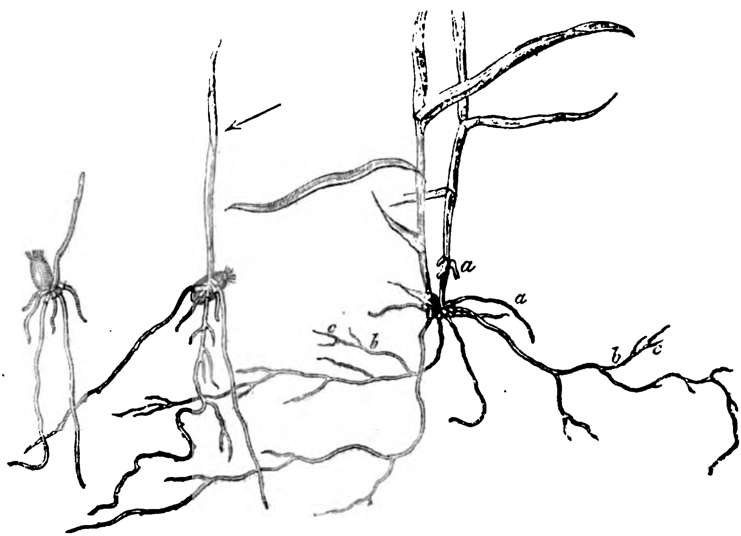


Fig. 1. Fig. 2. Fig. 3.

Diagram 4 (one-third of the actual size).—Winter wheat sown at different times.
Fig. 3. September, 1855. Fig. 2. January, 1856 Fig. 1. February, 1856.
a. Rootlets. b. Root fibres. c. Fibrils.

causing the starting of new roots, whilst the older roots branch into fibres and fibrils; still farther removed from the centre of

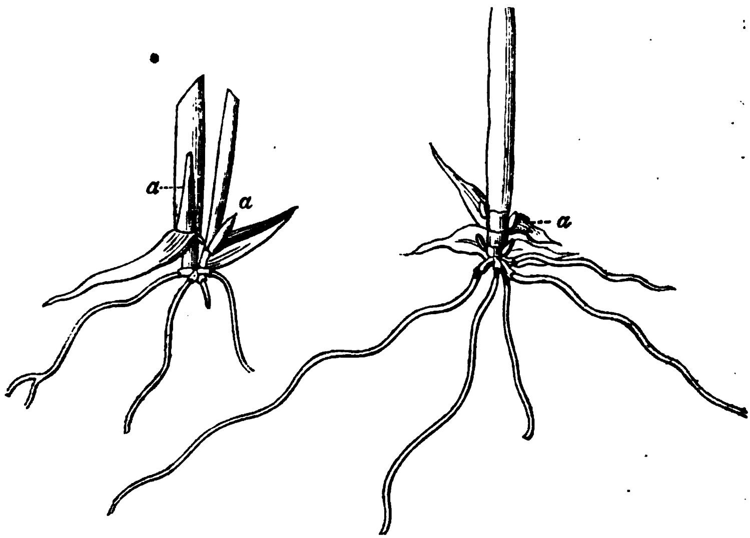


Fig. 2. Fig. 1.

Diagram 5.—*a, a, a.* Buds starting from the axills of the root-leaves, which are turned back to show them.

growth, the older rootlets providing for the necessities of the primitive plants, whilst the newer ones take care of the more recent buds.

This process of *tillering* is much interfered with by the following causes. A too thick sowing, like thick planting of trees, causes the plants to grow up thin and emaciated, and thus the central axis is elongated; in which case the lateral buds are not usually brought to perfection, or, if they do grow, it is only thin and irregularly, and without a disposition to *rebranch;* for it must be remembered that when lateral branches are strong they in turn give off others.

The thin mode of growth is induced in even thin sowing with a very mild autumn and winter, when the wheat is called winter-proud. Here, then, the winter has not succeeded in sufficiently crippling the upward growth of the plant; that is, *its development has not been arrested*, and this explains the principle upon which a hard winter is often beneficial to the wheat crop, and which has hitherto been attributed to slugs and insects being killed by the frost. Upon this point, however, it may be remarked, that the winter of 1854-5 was one of the severest of late years, yet insect life in the summer of 1855 was more

prolific than usual, the fact being, that for many weeks the ground was so hard and frozen that the natural enemies of these creatures were starving, such as birds, whilst the dormant insects suffered comparatively little, and were thus ready to come forth in myriads in early summer.

The foregoing remarks upon winter-proud wheat, or otherwise a poor crop, explain the action of feeding off thin or improperly tillered wheat by sheep, a mode of farming which in some districts is attended with the most beneficial results; whilst even the most unsparing use of the scythe we have seen to work wonders from a like cause.

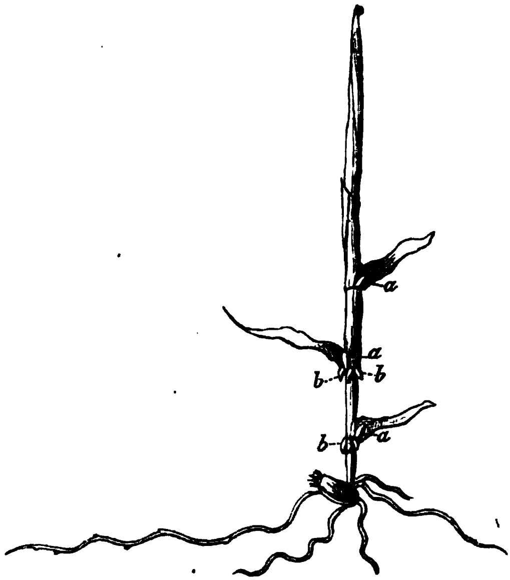


Diagram 6.—A lengthened axis of growth.
a, a, a. Buds. *b, b, b.* Rootlets.

Now as the processes hitherto described are dormant or active in proportion as the weather is colder or warmer, no sooner does the open weather of spring commence than a renewed action sets in in the growth of the wheat-plant. Many of the older fibres die in the winter, but in the spring new rootlets are pushed out, fresh fibrils branch from the fibres, and new buds are produced. This action goes on until the central axis has considerably elongated itself, when tillering ceases and the whole energy of the roots is devoted to supply the plant now rendered larger by increased leaves and increasing stems, when tillering altogether ceases, and the tillered stems, varying from 5 to 20, or even more, according to circumstances, produce ears of grain, which ripen pretty much at the same time.

In oats, lateral branches start from the axils of the leaves above ground, and hence tillered oats are mostly mixed with ripe and unripe branches.

These, then, are the circumstances usually attendant upon the growth of autumn-sown—usually called winter-wheat—it now

remains to consider the difference in these respects in that sown in spring.

In dealing with this question we must not forget that *spring and autumn wheat are not specifically distinct*, and that both the one and the other may be sown in any month of the year; a subject upon which I have experimented again and again, and thus given a spring wheat the habit of a winter one, and the reverse.

The following experiments with Red-Lammas wheat was carried out by myself in 1851-2. A plot of 5 yards square was drilled at 9 inches apart on the 14th day of each month of the year: if, however, that fell on a Sunday the next day after:—

Table of the Growth of Wheat in each Month of the Year.

Years.	Month.	Height.		Length of Head.	Remarks.
		Ft.	in.		
1851	June	3	5	3	Clean straw.
	July	2	10	2	Ditto.
	August	4	1	4	Ditto.
	September ..	3	11	4	Ditto.
	October	3	10	4	Rather blighted.
	November ..	3	9	4	Ditto.
	December ..	3	10	3½	Much blighted.
1852	January	3	10	3½	Ditto.
	February.. ..	3	6	4½	Ditto.
	March	..		..	Failed as a crop, but some ears ripened.
	April	..		..	
	May	..		..	

The winter was mild and wet. All the samples were gathered in August. The September, October, and November plots gave the best samples. That sown in March, April, and May was by far the worst of the series. Blight, both in straw and ear, was most prevalent from December through the spring months. That sown in June, July, August, and September was clean in the straw, but the ears of the July sample, though they ripened, were remarkably small.

From this experiment we see that although our wheat sown in the autumn months certainly succeeded best, yet that of the spring months gave a yield; and indeed winter varieties of wheat are often not sown until as late as the latter end of February; and we must remember that if winter wheat be left until the spring for sowing, it behaves, in its rooting and tillering, much as spring wheat; and hence, then, the difference is merely one of growth, and which may be described in a few words.

Winter wheat sends out new roots and fresh fibrils in spring, and at the same time tillers and forms tufts, each shoot of which also roots like the central blade, and all this second growth occurs just when spring wheat is coming up.

In spring wheat there is little disposition to tiller, as the growth is quick the root has no period of rest, and therefore its fibres and fibrils are developed regularly, and have no fresh impulse of growth like wheat that has stood the cold of winter, and is prepared to meet the milder season of spring, with an invigorated constitution and appetite that requires new roots and fresh rootlets to supply. It is on this account that winter wheat can be transplanted in spring with but little check to its growth, and even the tufts can be divided into slips, which is indeed a useful mode of augmenting our crop in experiments upon new and rare varieties.

In April of last year, 1855, I transplanted a plot of nursery wheat from a field on the farm to one of my experimental plots: it was put in rows eight inches apart and about two or three inches in the rows; the result of the experiment was, that scarcely a plant failed, the straw was good, and the ears of corn of unusual length, and besides, this plot became ripe not later than that in the field from which my plants were taken.

Another experiment with wheat may be here detailed as tending to show the general hardy nature of the wheat-plant. In October, 1849, I planted a small patch of wheat, which I kept constantly cut down during the summer of 1850, so as to prevent the formation of flowers: it stood the winter of 1850-1, and became a tolerable crop in the summer of 1851.

Now although the difference in growth of spring and winter wheat is merely one of degree, it yet entails upon the farmer a different mode of treatment. Winter wheat may be sown thin, especially if provision has not to be made against a superabundance of insects, such as wire-worms, slugs and the like.

A weak plant or a thin crop can often be repaired in their effects, by adopting processes to cause tillering, such as mowing, eating off with sheep, treading, and rolling. A new growth and fresh vigour can be imparted by special manures, to be presently more especially adverted to. And even transplantation may be had recourse to where it would pay for the trouble and expense.

With respect to *spring sown wheat*, as each seed only brings forth three or four ears, it should be planted thicker in the row and drill to insure its covering the ground, than in winter wheat; a treatment required in part, to prevent the ill effects of drought which is not unlikely to supervene. And as the soil has not a

winter before it to mellow and crumble it, it should be more carefully prepared, and if possible a more even and uniform depth of sowing should be adopted.

2. *Acclimatization.*—From what has been already advanced it will be seen that although wheat is adapted in its varieties to almost every degree of temperature, succeeding better in temperate than in tropical heat, it is yet derived from a wild grass whose natural habitat may be said to be that of a warm climate. Hence, then, the wheat-plant has great powers of adapting itself to circumstances, and this is not only so as regards the world at large, but we shall see, on inquiry, that even the slight inflexions of difference presented in our own island, nay, even in the uplands and lowlands of a single county, have a decided influence on the growth of the wheat-plant.

If we review the geography of a central county of England, for example, Gloucestershire, we shall see that it is divided into two districts—hill and vale: the flat valley of the Severn, extending from south to north for about 30 miles in length, and nearly 20 broad, has a range of hills on the eastern side, rising from the vale with a steep escarpment, thus forming the Cotteswold district, which presents variations in height to as much as 1,200 feet above the level of the sea. Now on these hills the prevailing sorts of wheat will be the hardier red varieties, whilst in the vale the finer white kinds are those planted on good, well-drained land; but in the stiff unmitigated lias clays the heavy, woolly-eared winter wheat is much cultivated on account of its enormous yield.

In choosing wheat for seed, attention should always be paid to the circumstances of climate and soil. I have many times tried to grow the spelt wheats from India, but have not succeeded in ripening it, though at first it grows away freely and gives great promise. Experiments now pending with *Ægilops* threaten failure from the difficulty of ripening the seed; but here, as I have the wild grass to deal with, and my object is to change it in form and habit, *acclimatization* will be an expected result of a continuance of the experiments.

Seed wheat should always be chosen from a poor soil for growth on a richer one, and from a cold climate for cultivation in a warmer: acting contrary to this rule often induces disease and a shortness in the yield. In Gloucestershire the hill farmer chooses seed from the exposed chalk wolds of Wilts, whilst the vale farmer gets his seed from the hills. But in the same manner as spring wheat may be cultivated into a winter variety, so may any sort of wheat become acclimatised by careful cultivation: this, however, sometimes entails a slight change of form, and hence have arisen tall and dwarf varieties, early and late forms, and

others far too numerous to be entered upon in this place. New varieties of wheat are constantly becoming the fashion with the agriculturist, but it must not be concluded that this is the result of caprice, as it is the nature of derivative plants to lose some of their qualities after a long career of changes, and hence varieties are always useful as a change; and the more distinctive these are, if adapted to our soil and climate, the better.

3. *Development: to what extent affected by top dressings at various periods of growth.*—It would be useless to reproduce in this place the many analyses that have from time to time been made of wheat, both as respects its straw and grain, or to attempt to show from these that the wheat-plant must obtain the ingredients of its structure from the media by which it is surrounded, as these are points which are settled both by practical experience and theoretical reasoning. We now know that where chemical matters are constantly being taken from the soil in crops, so must they be as constantly returned either by direct or indirect means, and in the growth of wheat we can apportion such substances either with a view to straw or grain in particular, and indeed almost determine for the production of an excess of a particular substance in either.

With respect to crops in general, *direct manuring* to encourage their growth is usually adopted. For the cereals, however, and especially wheat, this plan is seldom deemed advisable; but previous crops or a dunged winter fallow with roots are usually but preparatives in practice for the wheat crop, while *special manures* are used in various stages of growth or exigences in the progress of wheat.

Again, without attempting to decide the question in dispute as regards the *mineral theory* of the Baron Liebig, or the *nitrogenous manures* as experimented and written upon by Messrs. Lawes and Gilbert, we yet cannot avoid the conclusion that special nitrogenous manures applied to the growing wheat are for the most part remunerative, while the pure mineral manures are not: indeed the dictum, laid down of mineral manures being best adapted for roots and nitrogenous kinds for cereals, may, I think, be deemed a settled matter in practice. Admitting, then, this conclusion in its simplicity, I would here beg to point out a reason for the employment of *special nitrogenous manures* in cereal crops founded on an examination of the structure of the wheat leaves on the one hand, and of those of the turnip on the other, which, though it may in all probability affect future discussions upon this subject, are yet not meant as arguments in opposition to, or support of, one theory or the other.

If we examine the epidermis of the leaf of wheat both from the upper and under side with a magnifying power of about 250

diameters, we shall be able clearly to make out the *stomata* or breathing pores by which the leaf is dotted.—(Diagram 7.)

Now what we should here notice, is that as the wheat-plant grows *upright leaves*, and does not, like the turnip, present a flat under-side of these organs to the ground, so *the stomata in wheat are as thick on one side of the leaf as on the other*, a condition common to other upright growing plants, as the iris, pink, and the like.

The first sight, however, of a turnip-leaf shows that it differs greatly in this respect from that of the leaf of the wheat: the lighter colour of its under part evidencing that a very large majority of these pores are situate on the under as compared with the upper side.—(Diagram 8.)

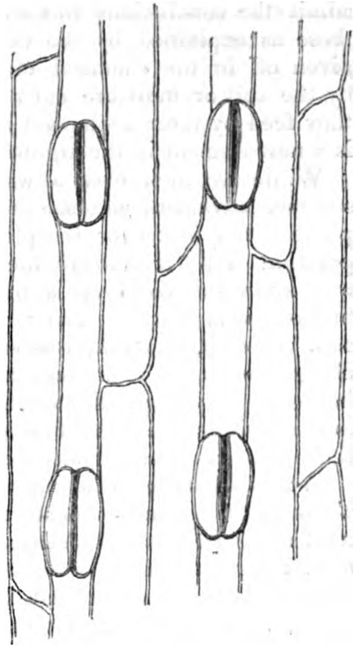


Diagram 7—Stomata of Wheat, about 250 diameters, $\frac{250}{1}$.

If, then, we for a moment consider that the leaves are the respiratory organs of plants, that they are concerned in the fixation of carbon and perhaps we may add of nitrogen, and that it is through the stomata that the carbonic acid for the carbon if not the ammonia for the nitrogen is respired, we shall, I think, be able to explain why the surrounding the wheat-plant with ammoniacal manures *at the season of its most vigorous growth* may be productive of benefit; and though we may in part

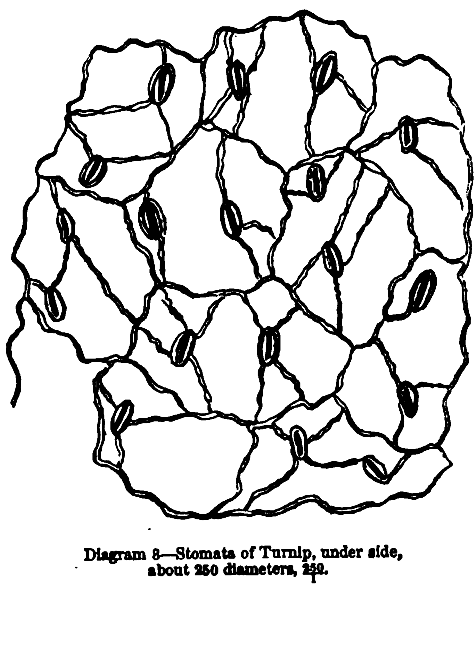


Diagram 8—Stomata of Turnip, under side, about 250 diameters, $\frac{250}{1}$.

admit the conclusions concerning the rationale of the action of these as explained by the chemist, namely, that the ammonia given off in the chemical changes of the manure is absorbed by the soil or moisture surrounding the plants and from which they feed by their roots, yet I cannot help thinking that here is a new element in the argument.

While we look over a wheat-field on a fine sunny day as summer advances, and see the dazzling dancing in the atmosphere a few feet over the plants, which is caused by the evaporation of water through the cellular system of the leaves, we may know that the crop is pumping up its food from the soil, but as this is just the time for liberating ammonia also from the soil, there is, I think, reason to believe that the atmosphere charged with carbonic acid and ammonia is at this very time being eagerly respired, and the reason for the development of root keeping pace with that of leaves, is that the functions of these two important organs should be duly balanced.

Wheat in its *growing history* is completed in a few weeks, although the production of strong plants for growth occupies, in the winter varieties, many months: and *it is just as the new growth commences* that ammoniacal manures are so beneficial, as the nitrogen therefrom has to be eliminated in a short time, and as the leaves are small and upright: if we suppose ammonia to be respired by them, they will require a quicker, and more constant and greater discharge of this gas, commencing too at a certain time, than is the case with a plant with large leaves which grow without any serious interruption from their birth, and whose under surface is the only inhaling one, and which is so arranged as to insure the due but more gradual and more certain performance of this office without loss; and hence, farm-yard manure, which is buried in the soil and which gradually decomposes, at first slowly, but faster the longer it is exposed to atmospheric and chemical actions, giving its inorganic matters in solution through the roots, whilst ammonia is given off into the atmosphere; indeed, so quickly in some of the warm, close days of the early part of September, that every farmer knows when this valuable crop is growing fast by the peculiar odour that he is then aware of in passing a turnip-field.

These remarks, though offered with a great degree of diffidence, as time for thought and experiment is wanting for its clearer elucidation, yet seems to open up a wide field for inquiry; at all events they would seem to show that, however complete our chemistry may be, yet in applying it to plant-growth the differences in the structure and habits of the plants must not be overlooked.

As regards the use of manures, the foregoing remarks would

tend to the recommendation of them as top-dressings for wheat, and to be used in the spring or very early summer. Such manures as are rich in ammonia, and of such a consistency or in such a condition as to be capable of giving off this gas equally and abundantly, are those most to be commended; and if my notions be correct, the circumstances which would tend to this, namely, warm days after occasional spring showers acting on a field in which the soil has been loosened by hoeing, are just those under which the wheat-plant would grow vigorously and well.

It should be mentioned that the crust which forms in some soils in winter should be loosened in spring, to facilitate this very action, as well as to destroy weeds, which latter should never be allowed in a wheat-field, as being a set of plants whose mode of respiration is different from the wheat; from which cause, and being nearer the soil, they rob the crop of some of its most valuable food, and so blighted straw and starved grain is nearly always the result of dirty farming.

It would make this Essay too long to advert to all the special manures which have been adopted for top-dressing of wheat; I shall therefore only remark upon a few that are most commonly used, of which the following is a short list:—

1. Decomposed or prepared night-soil.
2. Farm-yard dung.
3. Guano.
4. Nitrate of soda.
5. Soot.
6. Common salt.

If farm-yard manure or night-soil be applied as a top-dressing, it should be in a high state of decomposition, when it often acts very advantageously; but the difficulties attendant upon its application are so manifest as in a great degree to discourage their use. As respects night-soil, could it be rendered in a form in which it could be readily and equally distributed, its richness in nitrogenous matters and great abundance ought to ensure its very general adoption; but all plans to effect this have hitherto resulted in rendering it as dear, if not for its results dearer, than guano or special chemical substances.

Guano has been found in most hands to be a serviceable top-dressing for the wheat-crop: it is applied in various quantities, according to the previous cropping and the state and condition of the land; but much disappointment has been experienced in its use from its want of genuineness, or, if good, the state of the weather has much to do with its success.

Nitrate of soda is often mixed with guano in various proportions. I have seen 1 cwt. to 2 cwt. of guano to the acre produce very decided effects upon light soil. In this mixture it is likely

that the chemical decomposition is more equable and certain than in either separately; and besides, the nitrate of soda has such a great power of absorbing moisture, that in dry days and dewy nights much good must result from it in this way: this effect is probably heightened by mixing salt with nitrate of soda. In land tolerably well farmed, either after seeds or roots that have been eaten off on the soil, or if removed a dunged winter fallow,* if on light warm soils, nitrate of soda alone to the extent of 1 cwt. to the acre mixed with an equal quantity of salt has been found highly useful on the farm of the Royal Agricultural College: so I am informed by the Professor of Agriculture.

Soot, on stiff clay, usually called cold land, is the most constant top-dressing for wheat; this I have seen used for many years past at from 20 to 40 bushels per acre, and consider it useful not only from the ammonia and alkalis which it contains, but also to some extent from its colour inducing a more decided action of the sun's rays. It is upon this principle that the upland farmer, on thin brushy land, objects to its use, as it burns in dry weather.

Other nitrogenous manures might be mentioned, especially sulphate of ammonia and nitrate of potash, but in these their great price is an objection to their extensive use.

Salt, though not nitrogenous, is useful as a top-dressing on other accounts. A friend of mine always tops from 1½ to 2 cwt. per acre before ploughing the clover leys, in which case, besides any chemical action, it may be of great use in killing the larvæ of insects and destroying slugs. He says: "I consider it useful in checking an undue luxuriance of straw, and it decidedly reduces the amount of flag, and is, I think, of great use against mildew. We always get brighter straw after salt." That salt has a decided influence is now generally admitted. The chemist accounts for it on the supposition that it renders the silicates more soluble; but whatever its cause of action it seems quite true that though there is usually less straw when salt is employed, yet it is generally of a finer texture and far better in colour. The professor of agriculture at the Royal Agricultural College informs me, in speaking of the mixture of salt with nitrate of soda, that "though the salt is not without its beneficial effect, it is also useful in facilitating the distribution of the nitrate."

4. *Lifting Action of Frost, commonly called throwing out.*—Soils are very varied in their mechanical texture, according to which they are liable to great changes under atmospheric influences, amongst which the following are most common:—

* In land which has been by some accident defrauded of the manure which would ordinarily have fallen to its lot, the action of nitrate of soda is usually very beneficial.

a. Pulverization and Expansion after Frost.
b. Caking after rain.
c. Compression when filled with moisture.
d. Cracking in drought.

a. Some soils hold together with so little tenacity as to be shifted about by heavy winds with their crops upon them: this is often the case with soils made from the disintegration of the more silicious beds of the new red sandstone, an evil which can be prevented by a heavy dressing of the stiffer keuper marls of the same formation, which are usually not far removed from the sand, often forming the rounded knolls in Worcestershire, from whence the hauling is usually down hill with the load. These marls were formerly much used as a manure, but as they are found to contain no active principles, marling has been discontinued, but it might still be well to employ it as above as an ameliorator.

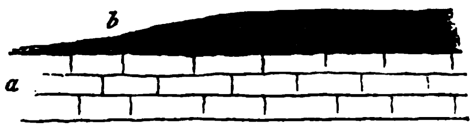


Diagram 9.—Section of New Red Sandstone.
a, Sandstones. *b*, Keuper marl.

Expansion, which causes the lifting action, takes place very generally in clunchy clays and marls containing much lime and argillaceous matter with but a comparatively small admixture of sand. Frost penetrates into its intestines and by its expansion in thawing crumbles the land to such an extent that it occupies a much greater space than it did in its more solid condition, and hence the lifting action by expansion. Some of the soils on the chalks and oolites are liable to this, and the result is that the wheat-plant is frequently lifted out of its place and left unplanted after the rains have once again rendered the soil more solid in its texture. This tendency is much mitigated in the winter wheat by tilth ploughing when after turnips, and here less pulverization is necessary: much more, however, after seeds, unless the land be tolerably free from weeds; but, on the other hand, the roots of seeds prevent lifting to a considerable extent.

Much of the injury from lifting is often prevented by the heavy rains by which frost is sometimes succeeded, which causes the soil to work down again around the roots, and in dry weather even to form a pellicle on the surface: this action may be greatly assisted by rolling, or, as is sometimes done, by sheep-treading in March, to be followed, however, by hoeing and top-dressing, in order to loosen the soil, and thus expose it with its chemical matters to the action of the atmosphere at the time of accelerated growth. The best method which I have observed to obviate the lifting tendency in soils liable to it is to get as large root crops as possible, and always leave the leaves to be ploughed in. This ulti-

mately tends to a more equable pulverization, and induces the formation of a loamy soil by a gradual admixture of vegetable matter. Farm-yard manure under furrow in such soils, unless very rotten, sometimes aggravates the evil of lifting, as its decomposition takes place but slowly, and straws of long dung are irregular conducting media for water and ice in the soil: it is for this, among other reasons, that direct manuring for wheat is not at all in favour certainly in the midland counties.

Expansion takes place in some of the stiff argillaceous lands of the lias and Oxford clays, in which much rain acts not by causing crumbling and lifting, but the enlarging of the plastic mass, which is compressed so tightly around the roots as to deprive these organs of free power of growth and action. This *plastic element* is very injurious to wheat from the comparative slowness with which chemical decomposition proceeds, as it does not readily let in either air or light, and besides it is unusually cold, as all land must be that so resolutely retains water. Here draining, clay-burning, dressing with town refuse, as ashes and the like, judicious cropping, the use of long dung, and indeed whatever contributes to the disintegration of its present texture, and admixture with other substances is of advantage. Under these circumstances of soil one can understand how it is that the farmer cannot always "get upon" his land—for in some seasons the plough would turn up clods only to be unbaked bricks, at others the whole would be a tenacious paste. On such soils again one does not wonder at the foxhunter calling it a "stiff country," or

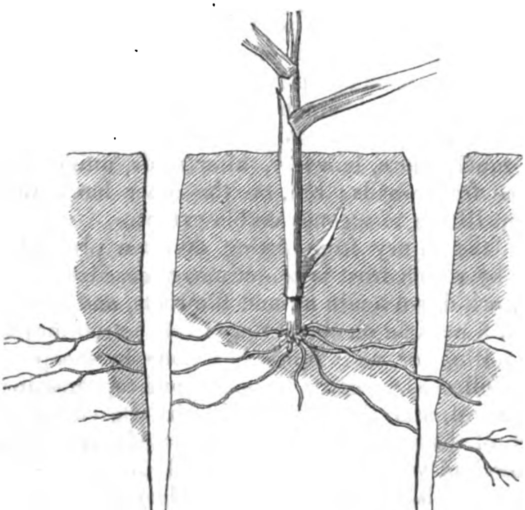


Diagram 10.—Showing the effects of the cracking of soil from drought.

that the farmer should feel especially anxious when the hounds are out, as evinced by the more than ordinarily earnest warning of "'ware wheat" in a field in which the marks of the horses feet would not be effaced for months.

Cracking in Drought is a condition to which stiff soils are peculiarly liable: this results in great injury to delicate-rooted plants, and especially wheat. If, for example, after a long continuance of March winds, the soil be cracked, as shown in the diagram (10), it follows that the fibres of the roots are rent, and then the secondary root growth is impeded, fibrils do not branch, and therefore when rain fills up the cracks (see diagram) new rootlets push out from the stems, by which process much time and vitality is lost: indeed, that power is being spent on reparation which should have been employed in tillering and general growth.

Feb., 1856.

VIII.—*On the Composition of Farmyard Manure, and the Changes which it undergoes on keeping under different Circumstances.* By Dr. AUGUSTUS VOELCKER, F.C.S., Prof. of Chemistry in the Royal Agricultural College, Cirencester.

IT is generally admitted that the management of farmyard manure, as carried out in many parts of England, more especially in the western counties, is often attended with much loss in valuable fertilising matters. In a country in which large sums are annually expended by the farming community in the purchase of artificial food and foreign manures, it might naturally be expected that the utmost care would be bestowed on the treatment of home-made dung, and that in its preparation the suggestions of improved practice and modern science would frequently be called into requisition by the cultivator of the soil. Experience, however, teaches that this is far from being the case. It is, indeed, a matter of surprise, no less to the agricultural chemist than to the more intelligent portion of the agricultural community, that there should exist on the one hand so much ignorance on the first principles involved in the management of farmyard manure, and on the other so much indifference as to the best means of preventing the deterioration of the most important of all fertilizers. For my own part, however, I cannot share the opinions of those zealous and, no doubt, sincere agricultural reformers, who describe the practical farmer as adverse to every new improvement, and turning a deaf ear to the suggestions of modern science. I know well how little of what commonly passes as a law of nature, or

a scientific principle, rests on a firm basis, and is derived from the constant recurrence of a number of well-established facts. I am well aware how many so-called improvements are the emanations of the heated imagination of empirical theorists, and how few of the suggestions of even eminent scientific men can be practically carried out with economy on a large scale. I therefore find it quite natural that the agriculturist, often bewildered, and scarcely knowing how to meet the difficulties that beset his path in carrying out modern improvements, should relapse into his old and accustomed course.

The inquiry into the changes which farmyard manure undergoes in keeping, under various modes of management, unquestionably is a subject of great importance; and I cannot help therefore expressing astonishment that it has not been taken up long ago, and submitted to a thorough and searching investigation. Hitherto our knowledge of this subject has been altogether very narrow, and this limited knowledge is of such a general character that it could not have been attended with any marked general improvement in the management of farmyard manure. General, and, in several respects, superficial information on so important a subject will as little assist the practical farmer in husbanding his home-made manure as similar information in the cultivation of root-crops would enable him to grow an abundant and remunerative crop of turnips. Agricultural chemistry, it strikes me, has reached that point at which, in order to become really useful to the practical man, it can no longer be prosecuted with success by amateur chemists, nor even by scientific chemists, who do not throw their whole energy into the inquiry, and give their undivided attention and time to this noble and eminently practical branch of applied science. This view appears to be daily gaining ground; and the time is fast approaching when agriculturists will no longer look with a certain suspicion on scientific investigations, but hail them with pleasure, aud willingly render that practical assistance which chemists have long earnestly desired. Many important inquiries, which neither the analyst in his laboratory nor the farmer in his fields can solve alone, will then be brought to a happy issue, and the principle which the Royal Agricultural Society has adopted for its motto, "Practice with Science," then, and then only, will bring forth its choicest blossoms, and be crowned with abundant fruit.

These thoughts were suggested to me on undertaking an extended inquiry into the changes which farmyard manure undergoes on keeping, under different modes of management; and I feel bound publicly to express my obligations to the enlightened Principal of our College, for the readiness with which he has met my wishes, and placed at my disposal horse and cart, men and

manure, and, in short, that practical apparatus, without which I could not have entered on the investigation. During a period of more than twelve months my leisure and that of my assistant, Mr. Sibson (to whom I feel greatly indebted for his persevering zeal and skill in this laborious task), has been almost constantly occupied in studying the changes which farmyard manure undergoes on keeping.

It is not my intention to write a paper on the best management of farmyard manure, a subject on which considerable diversity of opinion prevails. I may do so, probably, at a future occasion; for the present I purpose simply to lay before the reader the results of my practical and analytical experiments, and to accompany them with some remarks, which I trust may help to solve the question, how home-made dung ought to be prepared and kept in the most profitable manner, so as to develop the full efficacy of the excrements of our domestic animals, and the litter, and to guard against loss in the fertilising constituents of dung?

In undertaking this investigation I encountered a difficulty, which every one must have felt in experimenting on farmyard manure, namely, the difficulty of obtaining a sample sufficiently homogeneous to serve as the basis for future operations. In experimenting on fresh, or long dung, especially, it is no easy matter to incorporate the long straw uniformly with the more minutely divided droppings of animals; perhaps altogether a perfect mixture of both cannot be realised, and we must therefore be satisfied to make the mixture as intimate as the nature of the materials will permit. I endeavoured to reach this point by employing two men for the greater part of the day in turning a considerable quantity of fresh long dung, composed of horse, cow, and pig dung. By frequent turnings and distributions of the droppings amongst the long straw I thus obtained a tolerably uniform sample of mixed farmyard manure, which served as the basis for all future experiments and analyses with fresh dung. In the same way, but more easily, a well-mixed sample of well-rotten dung, composed of horse-dung, cows' and pigs' manure, was obtained a month later. This rotten dung, however, was not from the same heap from which the fresh dung last mentioned was obtained, but probably had undergone fermentation for a period of more than six months. It was well fermented, dark brown, almost black spit-dung, taken from the bottom of a corner of the manure-pit, where the more perfectly decomposed manure is used to be kept.

In order not to encumber the description of my experiments, and the statements of the results obtained in them, I shall give, in an Appendix to this paper, a brief account of the methods made use of in the performance of the following analyses. I may ob-

serve, however, in this place that the water-determinations in the experimental heaps were made on the same day on which they were put up, and that the samples for analysis were taken at the same time.

Fresh Farmyard Manure.

Difficult as it is to prepare several tons of dung of a tolerably uniform character for the experimental heaps, the difficulty is greatly enhanced when a sample fit for analysis has to be chosen. For analytical purposes large quantities are inadmissible; and it becomes therefore a matter of great importance thoroughly to prepare the small proportion of manure which can be employed in actual analysis as carefully as possible. To this end I spread out a weighed quantity of about 20 lbs. of fresh dung, previously well mixed in the manure-pit, thoroughly pulled it to pieces, and then allowed it to become air-dry, by keeping it for some days in a safe place, in a heated room. The partial loss in moisture having been ascertained by the difference in the second weight, as compared with that of the first: the whole of the partially dried manure was passed through a common coal-sieve; and the pieces of long straw which refused to pass through the meshes of the sieve were cut in small pieces with a large pair of scissors: 1 lb. of the partially dried and now much more thoroughly mixed manure was then dried in a water-bath, at 212°, until it ceased to lose in weight. The loss calculated for the original quantity of manure, and added to the loss which it sustained in becoming air-dry, gave the total percentage of moisture in the fresh dung. Another quantity of the partially dried manure, amounting to 1000 grains, was employed for the analysis, taken in hand on the 3rd of November, 1854.

This analysis furnished the following general results:—

General Composition of Fresh Long Dung (composed of Horse, Cow, and Pig Dung).

Made Nov. 3, 1855.

	In Natural State.	Calculated Dry.
Water	66·17	..
*Soluble organic matter	2·48	7·33
Soluble inorganic matter	1·54	4·55
†Insoluble organic matter	25·76	76·15
Insoluble inorganic matter	4·05	11·97
	100·00	100·00
* Containing nitrogen	·149	·44
Equal to ammonia	·181	·53
† Containing nitrogen	·494	·146
Equal to ammonia	·599	·177
Total per centage of nitrogen	·643	1·90
Equal to ammonia	·780	2·30

A delicate reddened litmus paper held over the fresh-mixed dung was not affected at first; but after the lapse of a couple of hours, the red colour was slightly changed into blue, thus showing that this fresh dung contained but a very small quantity of free or, properly speaking, volatile carbonate of ammonia; for it is in the state of carbonate, and never in a free and uncombined form, that ammonia is given off from putrefying substances.

I have endeavoured to determine quantitatively the amount of volatile compounds of ammonia in fresh manure, by distilling about 1000 grs., mixed with about 8 ounces of water, into a vessel containing dilute hydrochloric acid. This glass vessel was connected air-tight with the retort on the one hand, and on the other with a bulb apparatus, used in nitrogen combustions, and containing likewise dilute hydrochloric acid. By this means very small quantities of volatile ammoniacal compounds may be thoroughly fixed, and obtained, on evaporation of the acid, in the receiving vessel and bulb apparatus as chloride of ammonia. In this and the following analyses the amount of ammonia in the volatile ammoniacal compounds contained in manure is given, and, for brevity's sake, called free ammonia. At the same time I have endeavoured to ascertain the proportion of ammonia which, after the volatile ammonia compounds are distilled off, remains behind in the manure in a fixed state. This portion is mentioned in the analyses as ammonia in the state of salts. Both the free ammonia, and ammonia in the form of salts, are included in the determinations of the total amount of nitrogen (ammonia) contained in the manure.

The fresh manure analysed on the 3rd of November, 1854, contained in its natural state, and when perfectly dry—

	In Natural State.	Calculated Dry.
Per centage of free ammonia	·034	·10
„ ammonia in the state of salts	·088	·26

The amount of volatile ammonia, as well as ready formed ammonia, existing in the form of ammoniacal salts in fresh manure, thus appears to be very trifling.

Since there exists no complete, trustworthy analysis of the ash of fresh farmyard manure, I thought it advisable to analyse separately the soluble and the insoluble portion of the inorganic matters present in farmyard manure.

One hundred parts of the soluble inorganic matters in fresh farmyard manure were found to have the subjoined composition:—

Fresh Farmyard Manure.

Analysis made Nov. 3, 1854.

Composition of Ash of portion Soluble in Water.

Soluble silica	15·45
Phosphate of lime	19·44
Lime	4·30
Magnesia	·73
Potash	37·26
Soda	3·36
Chloride of Sodium	1·97
Sulphuric acid	3·49
Carbonic acid and loss	14·00
	100·00

The portion insoluble in water on analysis yielded the following results:—

Fresh Farmyard Manure.

Analysed Nov. 3, 1854.

Composition of Ash of portion Insoluble in Water.

Soluble silica	23·94
Insoluble silicious matter	13·86
Oxides of iron and alumina, with phosphates	14·73
Containing phosphoric acid	(4·41)
Equal to bone earth	(9·55)
Lime	27·92
Magnesia	3·54
Potash	2·46
Soda	·48
Sulphuric acid	1·76
Carbonic acid and loss	14·31
	100·00

In the next table the composition of the whole ash which was produced by this sample of fresh manure is stated:—

Fresh Farmyard Manure.

Analysis made Nov. 3, 1854.

Composition of the whole Ash.

Soluble in Water 27·55 per cent.	Soluble silica	4·25
	Phosphate of lime	5·35
	Lime	1·10
	Magnesia	·20
	Potash	10·26
	Soda	·92
	Chloride of sodium	·54
	Sulphuric acid	·22
	Carbonic acid and loss	4·71

Insoluble in Water 72·45 per cent.			Arranged together.
	Soluble silica	17·34	21·59
	Insoluble silicious matter (sand)	10·04	10·04
	Phosphate of lime	..	5·35
	Oxide of iron and alumina, with phosphates	8·47	8·47
	Containing phosphoric acid	(3·18)	(3·18)
	Equal to bone earth	(6·88)	(6·88)
	Lime	20·21	21·31
	Magnesia	2·56	2·76
	Potash	1·78	12·04
	Soda	·38	1·30
	Chloride of sodium	..	·54
	Sulphuric acid	1·27	1·49
	Carbonic acid and loss	10·40	15·11
		100·00	100·00

Before offering any remarks on the composition of fresh manure, it may be well to insert in this place a table representing the detailed composition of fresh farmyard manure:—

Composition of Fresh Farmyard Manure (composed of Horse, Pig, and Cow Dung, about 14 *days old).*

Analysis made Nov. 3, 1854.

Detailed Composition of Manure in Natural State.

Water		66·17
*Soluble organic matter		2·48
Soluble inorganic matter (ash):—		
Soluble silica	·237	
Phosphate of lime	·299	
Lime	·066	
Magnesia	·011	
Potash	·573	
Soda	·051	
Chloride of Sodium	·030	
Sulphuric acid	·055	
Carbonic acid and loss	·218	
		1·54
†Insoluble organic matter		25·76
Insoluble organic matter (ash):—		
Soluble silica	·967	
Insoluble silica	·561	
Oxide of iron, alumina, with phosphates	·596	
Containing phosphoric acid	(·178)	
Equal to bone earth	(·386)	
Lime	1·120	
Magnesia	·143	
Potash	·099	
Soda	·019	
Sulphuric acid	·061	
Carbonic acid and loss	·484	
		4·05
		100·00

* Containing nitrogen	·149
Equal to ammonia	·181
† Containing nitrogen	·494
Equal to ammonia	·599
Whole manure contains ammonia in free state ..	·034
" " in form of salts	·088

According to these results, the same manure in a perfectly dry condition will have the following composition:—

Detailed Composition of Fresh Farmyard Manure in Dry State.

*Soluble organic matter		7·33
Soluble inorganic matter (ash):—		
Soluble silica	·703	
Phosphate of lime	·884	
Lime	·185	
Magnesia	·033	
Potash	1·695	
Soda	·153	
Chloride of sodium	·089	
Sulphuric acid	·035	
Carbonic acid and loss	·772	
		4·55
†Insoluble organic matter		76·15
Insoluble inorganic matter:—		
Soluble silica	2·865	
Insoluble silica	1·659	
Oxide of iron and alumina, with phosphates	1·404	
Containing phosphoric acid	(·528)	
Equal to bone earth	(·822)	
Lime	3·335	
Magnesia	·424	
Potash	·294	
Soda	·077	
Sulphuric acid	·210	
Carbonic acid and loss	1·722	
		11·97
		100·00

* Containing nitrogen	·44
Equal to ammonia	·53
† Containing nitrogen	1·46
Equal to ammonia	1·77
Whole manure contains ammonia in free state	·10
" " in form of salts	·26

Fresh farmyard manure being composed of the droppings of horses, cows, and pigs, and the straw used for litter, according to the above determination, in round numbers consists of two-thirds of water and one-third of dry matters. Since this fresh manure was not more than fourteen days old, and no rain had fallen during the time it had lain in the dung-pit, all the water is due to the urine and the moisture of the droppings and litter. The quantity of straw employed as litter must necessarily affect the general composition of fresh dung, and more especially the amount of moisture which it contains; but, I believe, we are not far wrong by saying that fresh mixed dung, in the production of which litter has been liberally supplied to the animals, when

free from rain, consists of one-third of dry matters and two-thirds of moisture.

An inspection of the analytical results just mentioned will further bring to view several interesting particulars:—

1. *In fresh dung the proportion of soluble organic and mineral substances is small.* This circumstance fully explains the slow action of fresh dung when compared with the effect which well-rotten manure is capable of producing.

2. The proportion of insoluble matters, more especially of insoluble organic matters, in fresh dung, on the contrary, is very large. By far the larger proportion of the insoluble organic matters consists of straw, changed but little in its physical character and chemical composition.

In the sample of manure analysed the amount of insoluble organic matters is ten times as great as that of soluble organic matters, and the proportion of insoluble mineral substances nearly three times as large as the amount of soluble mineral matters.

3. Fresh dung contains a mere trace of ammonia in a volatile state of combination, and but a trifling quantity of ammonia in the form of ammoniacal salts.

4. The total amount of nitrogen contained in the *soluble portion* of fresh manure likewise is inconsiderable. Most of the nitrogen which, as we shall see by and by, is gradually liberated as the fermentation of dung progresses, is contained in the portion of the manure which is insoluble in water. In other words, comparatively speaking, little nitrogen exists in fresh dung in a state in which it can be assimilated by the growing plants. Thus, in the sample analysed, the readily available amount of nitrogen in 100 lbs. of fresh dung is only ·149 of a lb., whilst about four times as much nitrogen, or, in exact numbers, ·494 lb., occurs in the insoluble portion of 100 lbs. of fresh dung.

5. A comparison of the composition of the organic soluble matters with the composition of the organic insoluble matters of fresh dung, however, shows that the former are far more valuable than the latter, inasmuch as the soluble organic matters contain a very much larger percentage of nitrogen, and in a state of combination in which nitrogen is available to the immediate use of plants.

This will appear from the following numbers:—

100 parts of organic soluble matters in fresh dung contain	6·04	of nitrogen.
100 „ insoluble matters „ „	1·92	„

In the same weight of each there is thus more than three times as much nitrogen in the soluble organic matters as in the insoluble organic matters.

6. With respect to the inorganic or mineral constituents of fresh dung, it will be seen that it contains all those mineral matters which are found in the ashes of all our cultivated plants.

7. Comparing the composition of the soluble inorganic matters with that presented by the insoluble, no essential *qualitative* difference is perceived between both, for the same constituents which occur in the soluble ash are found also in the insoluble ash. But there exists a striking difference in the quantitative composition of the soluble and the insoluble mineral matters of fresh dung.

8. The principal constituent of the soluble ash of fresh dung, so far as quantity is concerned, is *potash;* 100 parts of soluble ash, it will be seen, contain no less than 37·26 parts of real potash, or a quantity which is equivalent to 54·7 of pure carbonate of potash. The analysis of the soluble portion of ash of fresh dung gave only 14 per cent. of carbonic acid, including the loss in analysis; and as 37·26 of potash take up 17·5 of carbonic acid in becoming carbonate of potash, and moreover much of the soluble lime existed in the water-solution as bicarbonate of lime, it is evident that a considerable quantity of potash is united with silicic acid in the soluble ash. The large percentage of soluble silica confirms this view; fresh farmyard manure thus contains much soluble silicate of potash.

9. The large amount of soluble silica, both in the soluble and in the insoluble ash, are deserving notice. In the soluble ash this silica is united principally with potash, and probably also with some soda; in the insoluble ash it is combined chiefly with lime, or exists in a finely divided state, in which it is readily soluble in dilute caustic potash.

10. The most prominent constituent of the soluble ash of fresh dung is silicate of potash.

11. The most prominent constituent of the insoluble ash is lime.

12. It is particularly worthy of notice that the soluble ash of even *perfectly fresh* dung contains a very *high percentage* of *phosphate* of *lime.*

The proportion of phosphate of lime in the soluble portion of ash was in fact found to amount to no less than 19½ per cent. of the whole soluble ash, whilst the percentage of phosphate of lime in the insoluble ash was found to be only 9½.

I must confess that I was not prepared to find so large an amount of a compound which is generally considered insoluble in water, and for this reason is not enumerated in the published analyses of farmyard manure amongst the soluble constituents of

dung. Repeated experiments, however, executed with all care to avoid any possible source of error, have shown me that water dissolves phosphate of lime or bone-earth much more rapidly and to a much greater extent than it has hitherto been supposed. This observation gains much in interest, if it be remembered that the late Mr. Pusey suggested many years ago a method of rendering bone-dust more efficacious as a manure for root-crops. His plan was to place bone-dust moistened with water and mixed with ashes, sand, or other porous matters in a heap, and to keep this heap moist by pouring occasionally water upon it, or, better still, stale urine or liquid manure. The suggestion has been followed by many with much success. But few may have known that by adopting Mr. Pusey's plan of reducing bone-dust still further they have been instrumental in generating that combination which gives peculiar value to superphosphate of lime, namely, soluble phosphate of lime.

In one of the latest numbers of the 'Annalen der Chemie und Pharmacie,' edited by Liebig, Wöhler, and Kopp, Professor Wöhler, of the University of Göttingen, makes the important observation that bone-dust moistened with a little water, in the course of a few days yields a considerable quantity of phosphate of lime to water, and that this solubility rapidly increases with the putrefaction of the gelatine of bones. My analysis of farmyard manure, made a year before the recent notice, which Professor Wöhler gave in the 'Annalen der Chemie,' respecting the solubility of phosphate of lime in water, may be regarded as a confirmation of Wöhler's direct experiments upon bone-dust, as well as an interesting scientific commentary on Mr. Pusey's practical suggestion of rendering bone-dust more efficacious as a manure for root-crops.

13. The insoluble part of the ash of fresh farmyard-manure includes the sand, earth, and other mineral impurities, which mechanically get mixed with the dung. Most of these impurities are mentioned in the ash-analyses as insoluble silicious matter; another portion is comprehended under oxides of iron and alumina with phosphates; and a third part, probably a considerable portion of the mechanical impurities, is included under lime, for the gravel and soil at Cirencester abounds in carbonate of lime.

Due allowance must be made for these mechanical impurities in all considerations respecting farmyard manure, otherwise conclusions will be drawn which the facts of the case do not warrant.

14. *Chemically considered Farmyard Manure must be regarded as a perfect and universal Manure.*—It is a universal manure, because it contains *all* the constituents which our cultivated crops

require to come to perfection, and is suited for almost every description of agricultural produce.

As far as the inorganic fertilising substances are concerned, we find in farmyard manure: potash, soda, lime, magnesia, oxide of iron, silica, phosphoric acid, sulphuric acid, hydrochloric and carbonic acid—in short, all the minerals, not one excepted, that are found in the ashes of agricultural crops.

Of organic fertilising substances we find in farmyard manure some which are readily soluble in water and contain a large proportion of nitrogen, and others insoluble in water and containing, comparatively speaking, a small proportion of nitrogen. The former readily yield ammonia, the latter principally give rise to the formation of humic acids and similar organic compounds. These organic acids constitute the mass of the brown vegetable substance, or rather mixture of substances, which, practically speaking, pass under the name of humus.

Farmyard manure is a perfect manure, because experience as well as chemical analysis shows that the fertilising constituents are present in dung in states of combination, which appear to be especially favourable to the luxuriant growth of our crops. Since the number of the various chemical compounds in farmyard manure is exceedingly great, and many no doubt exist in a different state of combination from that in which they are obtained on analysing farmyard manure, in our present state of knowledge it is impossible artificially to produce a concentrated, universal, and perfect manure, which might entirely supersede home-made dung.

I do not refer to the mechanical effect which farmyard manure is capable of producing. This mechanical effect, especially important in reference to heavy clay soils, ought to be duly regarded in estimating the value of common dung, but for the present it may suffice to draw attention to the fact, that even fresh dung contains a great variety of both organic and inorganic compounds of various degrees of solubility. Thus, for instance, we find in fresh manure volatile and ammoniacal compounds, salts of ammonia, soluble nitrogenized organic matters, and insoluble nitrogenized organic substances, or no less than four different states in which the one element, nitrogen, occurs in fresh manure. In well-rotten dung the same element, nitrogen, probably is found in several other forms. This complexity of composition—difficult, if not impossible, to imitate by art—is one of the reasons which render farmyard manure a perfect as well as a universal manure.

Rotten Farmyard Manure.

With a view of ascertaining the changes which farmyard manure undergoes in keeping, I submitted to analysis a well-

mixed sample of rotten dung produced under the same circumstances under which the fresh manure was obtained. The rotten dung probably was at least six months' old, possessed a dark-brown, almost black, colour, and appeared to be well-fermented, short dung.

The general composition of this dung is presented in the subjoined Table:—

Composition of well-rotten Manure (Mixed Horse, Cow, and Pig Dung).

Analyzed Dec. 5th, 1854.

	In natural state.	Calculated dry.
Water	75·42	..
*Soluble organic matter	3·71	15·09
Soluble inorganic matter	1·47	5·98
†Insoluble organic matter	12·82	52·15
Insoluble inorganic matter	6·58	26·78
	100·00	100·00
* Containing nitrogen	·297	1·21
Equal to ammonia	·360	1·47
† Containing nitrogen	·309	1·26
Equal to ammonia	·375	1·53
Total amount of nitrogen	·606	2·47
Equal to ammonia	·735	3·00

I have determined in this manure likewise the proportion of ammonia present in a volatile form, as well as the ammonia which is disengaged on distilling with quicklime the residue, from which the free ammonia has been driven off, and have obtained the following results:—

	In natural state.	Calculated dry.
Percentage of free ammonia	·046	·189
" ammonia in form of salts (readily decomposed by quicklime)	·057	·232

The proportion of free ammonia in well-rotten dung thus appears not much larger than in fresh dung produced under the same circumstances; and the amount of ammonia present in rotten dung in the form of salts, which are readily decomposed by quicklime, to be almost identical with that contained in the fresh manure. Further remarks on the composition of rotten dung I shall reserve until I have stated the composition of the soluble and insoluble ash and the detailed composition of the whole manure in its natural and dry state. In the following Table the composition of the soluble part of the inorganic matters in well-rotten farmyard manure is given:—

Analysis made Dec. 5, 1854.

Composition of Ash of Portion soluble in Water.

Soluble silica	17·31
Phosphate of lime	26·00
Lime	7·97
Magnesia	3·24
Potash	30·37
Soda	1·60
Chloride of sodium	2·53
Sulphuric acid	3·93
Carbonic acid and loss	7·05
	100·00

On comparing these analytical results with those obtained in the analyses of the soluble ash of fresh dung, it will be seen that the amount of soluble phosphate of lime (bone-earth) in the rotten dung is much greater than in the fresh. Phosphate of lime, next to potash, is the most abundant constituent of this ash.

Other differences between the soluble ash of fresh and rotten dung are too trifling to call for any special remarks. On the whole, a close similarity in the composition of both is sufficiently apparent.

The next table represents the composition of the insoluble ash of rotten dung:—

Analysis made Dec. 5, 1854.

Composition of Ash of Portion insoluble in Water.

Soluble silica	21·65
Insoluble silica	15·35
Oxides of iron and alumina and phosphates	14·40
Containing phosphoric acid	(4·17)
Equal to bone earth	(9·03)
Lime	25·34
Magnesia	1·38
Potash	·69
Soda	·58
Sulphuric acid	·96
Carbonic acid and loss	19·65
	100·00

The same constituents which occur in the insoluble ash of fresh manure are found in the insoluble ash of the rotten dung in very nearly the same relative proportions. The insoluble ash of rotten dung, however, contains still less potash, as nearly all potash is contained in the soluble ash.

From the foregoing results the composition of the whole ash left on burning of well-rotten dung has been calculated.

Analysis made December 5, 1854.

Composition of whole Ash.

			Arranged together.
Soluble in water, 18·27 per cent.	Soluble silica	3·16	
	Phosphate of lime	4·75	
	Lime	1·44	
	Magnesia	·59	
	Potash	5·58	
	Soda	·29	
	Chloride of sodium	·46	
	Sulphuric acid	·72	
	Carbonic acid and loss	1·28	
Insoluble in water, 81·73 per cent.	Soluble silica	17·69	20·85
	Insoluble silica	12·54	12·54
	Phosphate of lime	..	4·75
	Oxides of iron, alumina, with phosphates	11·76	11·76
	Containing phosphoric acid	(3·40)	(3·40)
	Equal to bone earth	(7·36)	(7·36)
	Lime	20·70	22·14
	Magnesia	1·17	1·76
	Potash	·56	6·14
	Soda	·47	·46
	Chloride of sodium	..	·76
	Sulphuric acid	·79	1·51
	Carbonic acid and loss	16·05	17·33
		100·00	100·00

As the relative proportion of soluble to insoluble ash differs in rotten from that in fresh dung, the composition of the whole ash of both presents some variations, observable especially in the amount of potash, which is much greater in the ash of fresh dung, and in a minor degree in the proportion of phosphate of lime.

In the next place I beg to direct attention to the subjoined Table, representing the detailed composition of rotten dung :—

Analysis made Dec. 5, 1854.

Detailed Composition of Manure in Natural State.

Water		75·42
*Soluble organic matter		3·71
Soluble inorganic matter (ash) :—		
Soluble silica	·254	
Phosphate of lime	·382	
Lime	·117	
Magnesia	·047	
Potash	·446	
Soda	·023	
Chloride of sodium	·037	
Sulphuric acid	·058	
Carbonic acid and loss	·106	
		1·47
Carry forward		80·60

Brought forward		80·60
†Insoluble organic matter		12·82
Insoluble inorganic matter (ash) :—		
Soluble silica	1·424	
Insoluble silica	1·010	
Oxides of iron and alumina, with phosphates	·947	
Containing phosphoric acid	(·274)	
Equal to bone earth	(·573)	
Lime	1·667	
Magnesia	·091	
Potash	·045	
Soda	·038	
Sulphuric acid	·063	
Carbonic acid and loss	1·295	
		6·58
		100·00

* Containing nitrogen	·297
Equal to ammonia	·36
† Containing nitrogen	·309
Equal to ammonia	·375
Whole manure contains ammonia in free state ..	·046
" " form of salts	·057

Dried at 212° F. the composition of this manure is as follows:—

Composition of the same Manure in dry state.

*Soluble organic matter		15·09
Soluble inorganic matter :—		
Soluble silica	1·035	
Phosphate of lime	1·554	
Lime	·476	
Magnesia	·193	
Potash	1·816	
Soda	·140	
Chloride of sodium	·151	
Sulphuric acid	·235	
Carbonic acid and loss	·380	
		5·98
†Insoluble organic matter		52·15
Insoluble inorganic matter :—		
Soluble silica	5·79	
Insoluble silica	4·11	
Oxides of iron and alumina, with phosphates	3·85	
Containing phosphoric acid	(1·11)	
Equal to bone earth	(2·41)	
Lime	6·78	
Magnesia	·37	
Potash	·18	
Soda	·15	
Sulphuric acid	·29	
Carbonic acid and loss	5·26	
		26·78
		100·00

* Containing nitrogen	1·21
Equal to ammonia	1·47
† Containing nitrogen	1·26
Equal to ammonia	1·53
Whole manure contains ammonia in free state ..	·189
" " form of salts	·232

The comparison of these analytical results with the numbers obtained in the analysis of the fresh manure, exhibits several striking differences, to some of which I beg to direct attention.

1. The well-rotten dung contains nearly 10 per cent. more water than the fresh. The larger percentage of water, it is true, may be purely accidental; but, considering the tendency of the liquid excrements to sink to the lower part of the manure pit in which the rotten dung accumulates, I believe rotten dung will always be found moister than fresh dung upon which no rain has fallen.

2. Notwithstanding the much larger percentage of moisture in the well-rotten dung, it contains in its natural state, with 75½ per cent. of water, almost as much nitrogen as the fresh dung, with only 66 per cent. of moisture. Supposing both to be equally moist, there would thus be considerably more nitrogen in rotten dung than in an equal weight of fresh. This is clearly observed by comparing the total amount of nitrogen in the perfectly dry fresh and rotten dung. In the former it amounts to 1·90 per cent. of nitrogen, in the latter to 2·47. As far as this most valuable element is concerned, farmyard manure becomes much richer, weight for weight, in becoming changed from fresh into rotten dung.

3. During the fermentation of the dung the proportion of insoluble organic matters greatly diminishes; thus the dry fresh manure contained 76 per cent. of insoluble organic matters, whilst there were only 52 per cent. in the dry rotten dung.

4. It is especially worthy of observation that, whilst the insoluble organic matter is much reduced in quantity during the fermentation, the insoluble organic matter which remains behind in rotten dung is richer in nitrogen than an equal quantity of insoluble organic matter from fresh dung. Thus 76 per cent. of insoluble organic matter of fresh dung contain 1·46 per cent., whilst 52 per cent. of it from rotten dung very nearly contain the same quantity, namely, 1·26. Or,—

100 parts of insoluble organic matter from fresh dung contain	1·92 per cent. of nitrogen.
100 parts of insoluble organic matter from rotten dung contain	2·41 " "

5. On the other hand, the relative proportion of insoluble inorganic matters increases much during the fermentation of the dung, since dry fresh dung contains about 12 per cent. of insoluble mineral matters, and dry well-rotten dungs 26·8 per cent., or more than double the amount which is found in fresh dung.

6. But perhaps the most striking difference in the compo-

sition of fresh and rotten dung is exhibited in the relative proportions of soluble organic matter. Well-rotten dung, it will be observed, contains rather more than twice as much soluble organic matters as the fresh; with this increase the amount of nitrogen present in a soluble state rises from ·44 per cent. to 1·21 per cent.

7. Not only does the absolute amount of soluble nitrogenised matters increase during the fermentation of dung, but the soluble organic matters relatively get richer in nitrogen also. Thus,—

100 parts of dry organic soluble matter from fresh dung contain	6·14 per cent. of nitrogen.
100 parts of dry organic soluble matter from rotten dung contain	8·02 " "

8. Lastly, it will be seen that the proportion of soluble mineral matters in rotten dung is more considerable than in fresh.

9. On the whole, weight for weight, well-rotten farmyard manure is richer in soluble fertilizing constituents than fresh dung, and contains especially more readily available nitrogen, and therefore produces a more immediate and powerful effect on vegetation.

Bearing in mind the differences observable in the composition of fresh and rotten dung, we can in a general manner trace the changes which take place in the fermentation of dung. Farmyard manure, like most organic matters, or mixtures in which the latter enter largely, is subject to the process of spontaneous decomposition, which generally is called fermentation, but more appropriately putrefaction. The nature of this process consists in the gradual alteration of the original organic matters, and in the formation of new chemical compounds. All organic matters, separated from the living organism, are affected by putrefaction, some more readily, others more slowly. Those organic substances which, like straw, contain but little nitrogen, on exposure to air and moisture at a somewhat elevated temperature decompose spontaneously and slowly, without disengaging any noxious smell. On the other hand, the droppings of animals, and especially their urine, which is rich in nitrogenous compounds, rapidly enter into decomposition, producing disagreeable-smelling gases. In a mixture of nitrogenous substances and organic matters free from nitrogen, the former are always first affected by putrefaction; the putrefying nitrogenised matters then act as a ferment on the other organic substances, which by themselves would resist the process of spontaneous decomposition much longer. Without air, moisture, and a certain amount of heat, organic matters cannot enter into putrefaction. These conditions exist in the droppings of cattle and the litter of the stables, hence putrefaction

soon affects fresh dung. Like many chemical processes, putrefaction is accompanied with evolution of heat. Air and water exercise an important influence on the manner in which the decomposition of organic matters proceeds. Both are absolutely requisite in order that putrefaction may take place. Perfectly dry organic substances remain unaltered for an indefinite period, as long as they are kept perfectly dry. But too large an amount of water, again, retards the spontaneous decomposition of organic substances, as it excludes the access of air and prevents the elevation of temperature, both of which conditions greatly increase the rapidity with which organic matters are decomposed. Although air is an essential element in the putrefaction of organic matters, the unlimited access is unfavourable to this process of spontaneous decomposition, and is productive of new changes. In farmyard manure the unlimited access of air is prevented by the compact nature of dung-heaps, consequently only a limited quantity of air can find its way into the interior of the mass. During the fermentation of fresh dung, disagreeable smelling gases are given off. These arise principally from the sulphur, and from the phosphorus of the nitrogenized compounds present in dung. A considerable proportion of this sulphur and the phosphorus combine with hydrogen, and form sulphuretted and phosphoretted hydrogen—two extremely nauseous gases, which both escape from fermenting dung-heaps. Another portion of the sulphur and the phosphorus unites with atmospheric oxygen, and in the presence of porous substances becomes changed into sulphuric and phosphoric acid, two non-volatile compounds, which are left behind.

We have seen the relative proportion of inorganic matters in well-rotten dung is much greater than in fresh. This increase in mineral matters can have only been produced on the expense of organic substances, the quantity of which during the process of fermentation must decrease in a corresponding relative degree. Thus the total amount of organic and inorganic matters in fresh dung, dried at 212° Fahr., is,—

Organic matters	83·48
Inorganic matters	16·52
	100·00

Whilst in rotten dung there are in 100—

Organic substances	68·24
Mineral substances	31·76
	100·00

It is clear therefore that, during the fermentation of dung, much of the organic substances must become changed into compounds which are either readily soluble in water, and easily washed out by heavy rains, or into gaseous products, which are readily volatilized. In point of fact, both volatile gases and readily soluble organic compounds are formed. Amongst the former, carbonic acid and ammonia deserve especial mention; amongst the latter, soluble humates and ulmates may be named. These ulmates and humates are dark-brown-coloured compounds of humic and ulmic acids, with the alkalies, potash, soda, and ammonia. Ulmic and humic acids in a free state are scarcely soluble in water, and for this reason colour it only light brown. These organic acids have a very powerful affinity for ammonia, in consequence of which they lay hold of any free ammonia, which is generated in the fermentation of dung, and fix it perfectly, as long as no other compound is present or produced in fermenting dung, which at an *elevated temperature* again destroys the union of ammonia with humic, ulmic, and similarly constituted acids. Now, ammonia is generated during the putrefaction of the nitrogenized constituents of dung in large quantities, and would be dissipated into the air much more rapidly than is the case in reality, if there were not formed in the dung itself a group of organic compounds, which act as most excellent fixers of the volatile ammonia. I refer to the humus substances, which are gradually produced from the non-nitrogenized constituents of dung. In other words, the straw employed as litter during the putrefaction of dung is to a great extent converted into humic and ulmic acids, which fix to a certain extent the ammonia produced from the more nitrogenous excrementitious matters. The pungent smell of fermenting dung, however, shows that the volatile ammonia cannot be fixed entirely by these means. In the course of this inquiry I shall point out the reason of this, and content myself in this place by saying that the proportion of ammonia which passes into the atmosphere from fermenting dung-heaps, and the loss which hereby is occasioned, is much less considerable than it is generally assumed to be. In fermenting dung-heaps the carbonaceous constituents at first are changed into humus substances, but these are rapidly oxidized by atmospheric oxygen, and partly changed into carbonic acid, a gaseous substance which, in conjunction with oxide of carbon and carburetted hydrogen, is given off abundantly from all putrefying organic matters.

I have endeavoured to describe briefly the principal changes which take place in the fermentation of farmyard manure. It has been shown:—

1. That during the fermentation of dung the proportion of both soluble organic and soluble mineral matters rapidly increases.

2. That peculiar organic acids, not existing—at least, not in considerable quantities—are generated, during the ripening of dung from the litter and other non-nitrogenized organic constituents of manure.

3. That these acids (humic, ulmic, and similar acids) form, with potash, soda, and ammonia, dark-coloured, very soluble compounds. Hence the dark colour of the drainings of dung-heaps.

4. That ammonia is produced from the nitrogenous constituents of dung, and that this ammonia is fixed, for the greater part, by the humus substances produced at the same time.

5. That a portion of the sulphur and phosphorus of the excrementitious matters of dung is dissipated, in the form of sulphuretted and phosphoretted hydrogen.

6. That volatile ammoniacal compounds, apparently in inconsiderable quantities, escape into the air.

7. That the proportion of organic substances in fresh dung rapidly decreases during the fermentation of dung, whilst the mineral substances increase in a corresponding degree.

8. That this loss of organic substances is accounted for by the formation of carbonic acid, oxide of carbon, and light-carburetted hydrogen, or marsh-gas.

9. That the proportion of nitrogen is larger in rotten than in fresh dung.

The practical result of these changes is, that fresh manure, in ripening, becomes more concentrated, more easily available to plants, and, consequently, more energetic and beneficial in its action. It may be questioned, with much propriety,—Is this apparently desirable result attained without any appreciable loss? or is it realised at too great an expense? In other words, Is the fermentation of dung, or is it not, attended with considerable loss of really valuable fertilizing substances?

In putting this question we have to bear in mind that the loss in valuable mineral matters, under proper management, practically speaking, can be avoided, since they are non-volatile, and, therefore, must remain incorporated with the dung, if care be taken to prevent their being washed away by heavy falls of rain. We have likewise to bear in mind that, in an agricultural point of view, the carbonaceous, non-nitrogenized manure-constituents do not possess a very high intrinsic value; and that we therefore need not trouble ourselves about their diminution, if it can be shown that it is accompanied with other beneficial changes. The

only other constituents which can come into consideration are the nitrogenized matters. The question may therefore be thus simplified: Is the fermentation of farmyard-manure necessarily attended with any appreciable loss in nitrogen?

Any one may ascertain that fermenting dung gives off ammonia, by holding over a dungheap, in active fermentation, a moistened reddened litmus-paper. The change of the red colour into blue sufficiently shows that there is an escape of ammonia. However, this experiment does not prove as much as is sometimes believed; for inasmuch as the most minute traces of ammonia produce this change of colour, the escape of this volatile fertilizing matter may be so small that it is practically altogether insignificant. The comparison of fresh with rotten dung, we have seen already, does not decide whether or not fresh farmyard manure sustains a loss in nitrogen in becoming changed into rotten manure. Apparently there is a gain in nitrogen, for we have seen that rotten dung contains more nitrogen than fresh. This gain in nitrogen, however, is explained by the simultaneous disappearance of, relatively, a much larger quantity of carbonaceous organic matter. Still the accumulation of nitrogen in rotten dung is important, and hardly to be expected; for, since a considerable portion of the nitrogenized organic matters is changed into volatile ammonia during fermentation, a loss, instead of a gain, in nitrogen naturally might be expected. A much greater loss in nitrogen than is actually experienced would, indeed, take place during the fermentation of dung, if this process were not attended with the simultaneous formation within the manure-heap of excellent fixers of ammonia.

Already at the beginning of my experiments I was thoroughly convinced that the mere analysis of farmyard manure would not decide the question which has just been raised, and therefore at once determined to make the analyses in conjunction with direct weighings of dung in various stages of decomposition. To this end I weighed out carefully two cartloads-full of the same well-mixed sample of fresh farmyard manure, the full analysis of which is given in the preceding pages. The manure was placed in a heap set against a stone wall, but otherwise exposed to the influence of the weather. The entire crude loss which this experimental heap sustained in the course of time was ascertained by periodical weighings on the weighbridge. Simultaneously with these weighings the manure was submitted to analysis, and thus I was enabled not only to determine from time to time the loss in weight which the experimental heap sustained in keeping, but also to ascertain which constituents were affected by this loss, and in which relative proportions. I shall

call this experimental heap "Fresh Farmyard Manure, No. I., Exposed."

Another object I had in view was to examine the relative merits of various practical methods of the treatment of dung on the farm. This I endeavoured to attain by a series of strictly comparative practical and analytical experiments. For this purpose, I carefully weighed out two additional cartloads of fresh, well-mixed farmyard manure, taken from the same heap from which the experimental heap, No. I., was formed. It was placed next to the heap No. I., but sheltered from rain, sun, and sweeping winds by being kept under a shed. This heap will be described, in the following pages, as "Fresh Farmyard Manure, No. II., Under Shed."

In order to examine the merits of making farmyard manure in open yards, I weighed out 1 cartload of the same fresh, well-mixed manure, and spread it evenly to about the same thickness in which manure is found under cattle in open yards, in an enclosed space, in close proximity to the other experimental heaps. This heap is called "Fresh Farmyard Manure, No. III., Spread."

Finally, I put up a small heap of the same well-rotten dung, the analysis of which has been stated above. Like the experimental heap No. I., it was placed against a stone wall, but otherwise exposed to the influence of the weather. Under the name of "Well-rotten Farmyard Manure, No. IV., Exposed," it will be described in the succeeding pages.

All four experimental heaps were again weighed on the 14th of February, 1855, after having thus been kept for 3 months and 11 days. At the same time at which the weighings were made, samples of each were taken for analysis, and the water-determinations made immediately. Unfortunately, I discovered, just when the last heap was placed on the weighbridge, that the frost had impaired the accuracy of the balance, and I had, therefore, no alternative but to reject the weighings in toto, and can supply therefore for this month only the analyses. This is the more to be regretted, as I submitted samples of three of the experimental heaps to a strict and detailed analysis. I trust, however, the subjoined analyses will not be void of interest.

The following Table exhibits the composition of "Experimental Heap No. I., Exposed," in its natural state :—

Composition of Fresh Farmyard Manure (No. I.), *Exposed, in Natural State.*

Taken for analysis, Feb. 14, 1855.

Water		69·83
*Soluble organic matter		3·86
Soluble inorganic matter (ash):—		
Soluble silica	·279	
Phosphate of lime	·300	
Lime	·048	
Magnesia	·019	
Potash	1·096	
Soda	·187	
Chloride of sodium	·106	
Sulphuric acid	·160	
Carbonic acid and loss	·775	
		2·97
†Insoluble organic matter		18·44
Insoluble inorganic matter (ash):—		
Soluble silica	·712	
Insoluble silica	·857	
Oxide of iron and alumina, with phosphates	·810	
Containing phosphoric acid	(·177)	
Equal to bone earth	(·277)	
Lime	1·291	
Magnesia	·029	
Potash	·127	
Soda	·046	
Sulphuric acid	·099	
Carbonic acid and loss	·929	
		4·90
		100·00

* Containing nitrogen	·27
Equal to ammonia	·32
† Containing nitrogen	·47
Equal to ammonia	·57
Whole manure contains ammonia in free state	·019
" " in form of salts	·064

The same manure, in a perfectly dry state, contains in 100 parts:—

* Soluble organic matter		12·79
Soluble inorganic matter (ash):—		
Soluble silica	·924	
Phosphate of lime	·985	
Lime	·160	
Magnesia	·065	
Potash	3·632	
Soda	·621	
Chloride of sodium	·351	
Sulphuric acid	·532	
Carbonic acid and loss	2·570	
		9·84
Carry forward		22·63

Brought forward		22·63
†Insoluble organic matter		61·12
Insoluble inorganic matter:—		
Soluble silica	2·364	
Insoluble silica	2·844	
Oxides of iron and alumina, with phosphates	2·689	
Containing phosphoric acid	(·589)	
Equal to bone earth	(·919)	
Lime	4·281	
Magnesia	·097	
Potash	·422	
Soda	·166	
Sulphuric acid	·329	
Carbonic acid and loss	3·066	
		16.25
		100·00

* Containing nitrogen	·91
Equal to ammonia	1·10
† Containing nitrogen	1·55
Equal to ammonia	1·88
Whole manure contains ammonia in free state ..	0·62
" " in form of salts ..	·212

Composition of Ash of portion Soluble in Water of the same Manure.

Soluble silica	9·40
Phosphate of lime	10·12
Lime	1·63
Magnesia	·67
Potash	36·92
Soda	6·32
Chloride of sodium	3·57
Sulphuric acid	5·41
Carbonic acid and loss	25·96
	100·00

Composition of Ash of portion Insoluble in Water of the same Manure.

Soluble silica	14·55
Insoluble silicious matter (sand)	17·50
Oxides of iron and alumina, with phosphates ..	16·55
Containing phosphoric acid	(3·63)
Equal to bone earth	(5·66)
Lime	26·35
Magnesia	·60
Potash	2·60
Soda	·95
Sulphuric acid	2·03
Carbonic acid and loss	18·87
	100·00

In the next Table is given the composition of the whole ash left on burning the manure.

Composition of whole Ash of Fresh Farmyard Manure (No. I.), *Exposed*

			Arranged together.
Soluble in Water 37·74 per cent.	Soluble silica	3·55	
	Phosphate of lime	3·82	
	Lime	·62	
	Magnesia	·25	
	Potash	13·93	
	Soda	2·38	
	Chloride of sodium	1·35	
	Sulphuric acid	2·04	
	Carbonic acid	9·80	
Insoluble in Water 62·26 per cent.	Soluble silica	9·06	12·61
	Insoluble silica	10·89	10·89
	Phosphate of lime	..	3·82
	Oxide of iron and alumina, with phosphates	10·30	10·30
	Containing phosphoric acid	(2·26)	(2·26)
	Equal to bone earth	(3·52)	(3·52)
	Lime	16·41	17·03
	Magnesia	·37	·62
	Potash	1·62	15·55
	Soda	·59	2·97
	Chloride of sodium	..	1·35
	Sulphuric acid	1·27	3·31
	Carbonic acid	11·75	21·55
		100·00	100·00

A comparison of these analytical results with the analysis which was made of the fresh manure, on the 3rd of November, 1854, will show :—

1. That there is more water in the manure on the 14th of February, 1855.

2. That, notwithstanding the larger proportion of water, the soluble organic and mineral matters have become more abundant, whilst the insoluble organic matters have become diminished in quantity.

Thus, in November, the manure contained 2·48 per cent. of soluble organic matter, and 1·54 mineral substances; and in February, 3·86 per cent. organic and 2·97 mineral substances; whilst the proportion of insoluble organic matters in November amounts to 25·76 per cent., and in February to only 18·44 per cent.

These differences are still more striking, if we make the comparison with the perfectly dry manure. It will then be found that the manure contained :—

	Nov. 3, 1854. per Cent.	Feb. 14, 1855. per Cent.
Soluble organic matters	7·33	12·79
Soluble mineral matters	4·55	9·84
Insoluble organic matter	76·15	61·12
Insoluble mineral matters	11·97	16·25
	100·00	100·00

3. That the total percentage of organic substances decreases, whilst that of mineral matters increases. Thus the fresh manure contained—

	In Nov.	In Feb.
Organic matters	28·24	22·30
Mineral matters	5·59	7·87

And the perfectly dry manure—

Organic matters	83·48	73·91
Mineral matters	16·52	26·09

4. That the percentage of nitrogen in the February analysis is slightly greater than in November.

5. That there is about the same inconsiderable amount of free ammonia, and ammonia in the form of readily decomposable salts, in the manure in February which has been found in November, 1854.

6. With respect to the inorganic constituents, a careful perusal of the furnished ash-analyses will show that the soluble portion of the ash of the February manure contains less phosphates of lime and less soluble silica, but more sulphuric acid, than the soluble ash of the perfectly fresh manure analyzed in November. The insoluble portion of the ash in February likewise contains less phosphates and soluble silica than in November, and the same differences will be observed on comparing the whole ash of February with that of November. It would appear thus that a three months' exposure to the weather has had the effect of removing from the manure an appreciable quantity of two very important fertilizing substances, namely, phosphate of lime (bone-earth) and soluble silica.

I purposely abstain from pointing out minor differences, which will be observed in the November and February analyses of this manure; for it must be borne in mind that, in experiments with farmyard manure, a perfectly uniform mixture can scarcely be obtained. Minor variations in the composition of the manure of November and February, therefore, may result as likely from purely accidental causes as from any real difference in composition. The particulars, however, just mentioned are sufficiently marked to prove that they are not due to accident, but to a series of changes which the fresh manure has undergone in the course of 3 months and 11 days.

Fresh Farmyard Manure (No. II.), *Under Shed.*—Put up Nov. 3, 1854. Analyzed again in Feb. 14, 1855.

The fresh manure used for all experiments was rather dry, no rain having fallen during the fortnight, in which the dung was collected from the stable, cow-house, and piggeries.

Plenty of litter having been supplied to the animals, the fresh manure appeared to me drier than usual, and as the experimental heap under shed necessarily must lose a good deal of moisture on keeping, I thought it desirable to pour water upon it, just sufficient to make it as moist as fresh dung generally appears. This addition of water, which was not repeated, explains that the manure under shed contained a little more moisture in February, 1855, than when first put up in November, 1854.

The following Table exhibits the composition of this manure in its natural state:—

Fresh Farmyard Manure (No. II.), *Under Shed.*

Analysis made Feb. 14th, 1855.

Composition of Manure in natural state.

Water		67·32
*Soluble organic matter		2·63
Soluble inorganic matter (ash):—		
Soluble silica	·239	
Phosphate of lime	·331	
Lime	·056	
Magnesia	·004	
Potash	·676	
Soda	·192	
Chloride of sodium	·058	
Sulphuric acid	·119	
Carbonic acid and loss	·445	
		2·12
†Insoluble organic matter		20·46
Insoluble inorganic matter (ash):—		
Soluble silica	1·893	
Insoluble silicious matter (sand)	1·075	
Oxide of iron and alumina, with phosphates	1·135	
Containing phosphoric acid	(·298)	
Equal to bone earth	(·646)	
Lime	1·868	
Magnesia	·078	
Potash	·208	
Soda	·038	
Sulphuric acid	·098	
Carbonic acid and loss	1·077	
		7·47
		100·00

* Containing nitrogen	·17
Equal to ammonia	2·06
† Containing nitrogen	·58
Equal to ammonia	·70
Whole manure contains ammonia in free state	0·22
" " in form of salts	0·54

Composition of the same Manure in dry state.

*Soluble organic matter		8·04
Soluble inorganic matter (ash):—		
Soluble silica	·733	
Phosphate of lime	1·013	
Lime	·171	
Magnesia	·013	
Potash	2·068	
Soda	·578	
Chloride of sodium	·179	
Sulphuric acid	·366	
Carbonic acid and loss	1·359	
		6·48
†Insoluble organic matter		62·60
Insoluble inorganic matter:—		
Soluble silica	3·294	
Insoluble silica	5·800	
Oxide of iron and alumina, with phosphates	3·477	
Containing phosphoric acid	(·91)	
Equal to bone earth	(1·979)	
Lime	5·722	
Magnesia	·240	
Potash	·613	
Soda	·116	
Sulphuric acid	·302	
Carbonic acid and loss	2·316	
		22·88
		100·00

* Containing nitrogen	·53
Equal to ammonia	·66
† Containing nitrogen	1·77
Equal to ammonia	2·14
Whole manure contains ammonia in free state	0·67
" " in form of salts	1·65

One hundred parts of the *soluble portion* of the mineral matters of the same manure contain:—

Soluble silica	11·32
Phosphate of lime	15·64
Lime	2·64
Magnesia	·21
Potash	31·92
Soda	9·07
Chloride of sodium	2·77
Sulphuric acid	5·66
Carbonic acid and loss	20·77
	100·00

One hundred parts of the insoluble portion of the ash of the same manure furnished the following results:—

Soluble silica	25·35
Insoluble silica	14·40
Oxide of iron and alumina, with phosphates	15·20
Containing phosphoric acid	(4·00)
Equal to bone earth	(8·66)
Lime	25·01
Magnesia	1·05
Potash	2·73
Soda	·51
Sulphuric acid	1·32
Carbonic acid and loss	14·43
	100·00

Taking into account the relative proportions in which the soluble mineral matters are mixed with the insoluble in this manure, the composition of the whole ash left, on burning of the manure, has been calculated.

Composition of whole Ash, produced by the same Manure.

			Arranged together.
Soluble in water, 22·10 per cent.	Soluble silica	2·50	
	Phosphate of lime	3·45	
	Lime	·58	
	Magnesia	·04	
	Potash	7·05	
	Soda	2·03	
	Chloride of sodium	·61	
	Sulphuric acid	1·25	
	Carbonic acid and loss	4·59	
Insoluble in water, 77·90 per cent.	Soluble silica	19·74	22 24
	Insoluble silica	11·21	11·21
	Phosphate of lime	..	3·45
	Oxide of iron and alumina, with phosphates	11·84	11·84
	Containing phosphoric acid	(3·11)	(3·11)
	Equal to bone earth	(6·74)	(6·74)
	Lime	19·48	20·06
	Magnesia	·82	·86
	Potash	2·12	9·17
	Soda	·39	2·42
	Chloride of sodium	..	·61
	Sulphuric acid	1·02	2·27
	Carbonic acid and loss	11·28	15·87
		100·00	100·00

On comparing these results with the analyses of the fresh manure of November, 1854, it will be found that the manure kept under the shed for 3 months and 11 days has suffered very little change both as regards organic and mineral constituents. It will be perceived that the proportion of soluble compounds has very little increased in the course of this time, and that the percentage of nitrogen in the manure, practically speaking, has remained unaltered. Thus comparing the composition of the dry manure of February with that of the fresh of November, it will

be seen that the fresh manure contained in November 7·33 of soluble organic matter, and in February hardly 1 per cent. more, namely, 8·04 per cent.

In the fresh, the percentage of nitrogen in the soluble organic matter is ·44, and in the same manure kept 3 months 11 days under shed, the nitrogen amounts to ·53 of a per cent. It also contains but a trifling amount of free ammonia, and ammonia in the form of salts.

Apparently the manure has lost a good deal of organic insoluble matter, almost as much as the exposed heap. If, however, we scrutinize the results obtained in the analysis, it will be seen that the manure under shed contains a more considerable proportion of insoluble ash, and in this more lime and insoluble silicious matter, than occurs in the experimental heap (No I.) exposed to the weather for the same length of time. In the latter the mineral insoluble matter we would naturally expect to increase, since the soluble constituents are exposed to the solvent action of falling rain. The manure under shed cannot be subject to this deteriorating influence. If we find, notwithstanding, more insoluble mineral matters than in the manure exposed to the weather, it is plain that the larger amount of insoluble mineral matters, which causes the apparent diminution of insoluble organic compounds, can only be due to a larger proportion of mechanical earthy impurities in the sample analysed. In proof of this view of the matter it may further be stated that the manure kept under shed for another 3 months furnished even a little less insoluble mineral matter than in February. And as in the warmer spring months a more considerable diminution of organic substances has really taken place, as shown by the analyses to be mentioned hereafter, the excess of insoluble mineral matters in the February analysis can only be accounted for by mechanical impurities in the sample of which the analysis has been made.

If we make due allowance for this disturbing influence, it will be observed that the composition of the soluble and insoluble portion of the ashes, furnished by the fresh manure in November, and of the same heap kept under shed for 3 months 11 days, is almost identical. It deserves to be noticed specially, that the ash of the manure kept under shed contains more phosphate of lime (bone-earth) than the ash produced by the heap exposed to the weather for the same length of time, during which the second experimental heap has been kept under shed.

I also beg to direct attention to the fact that this manure, as well as the preceding experimental heap, contains more sulphuric acid than the heap when first put up. On keeping of dung some of the sulphur, which we know occurs in nitrogenized substances in a peculiar state of organic combination, appears to

become oxydised and changed into sulphuric acid, which acid entering into combination with lime, produces in its turn gypsum. Farmyard manure thus contains a quantity of gypsum, which becomes more considerable as the fermentation of the dung proceeds. Without pushing deductions from this fact too far, it may be observed that it is interesting at all events to find that in the fermentation of dung, gypsum, a well known fixer of ammonia, is produced simultaneously with volatile compounds of ammonia.

Besides the humus-like organic substances which we have seen are produced in fermenting dung-heaps, an additional fixer of ammonia, *i.e.* gypsum, is generated; and thus great care is manifested by nature to prevent, if possible, the loss of this valuable fertilizing substance.

Fresh Farmyard Manure (No. III.), *Spread.*

The manure being covered with snow on the 14th of February, when the other experimental heaps were analysed, and it having been found next to impossible to remove the snow completely, or to mix it thoroughly with the manure, nothing was done in this month with the spread experimental farmyard manure.

Well-rotten Dung (No. IV.), *Exposed.*—Put up Dec. 5, 1854. Analysed again, Feb. 14, 1855.

This experimental heap has been exposed to the influence of the weather for a period of 2 months and 9 days. During that time it had shrunk considerably in size. The diminution in bulk, however, I believe, is not so much the result of an actual very great loss, as it is due to the manure gradually settling down and becoming firmer. Still it has undergone some loss in keeping even during the cold time of the year, as will be seen from the subjoined analyses.

In the state in which the well-rotten dung was analysed on the 14th of February it furnished the following results:—

Well-rotten Farmyard Manure (No. IV.), *Exposed.*

Analysis made Feb. 14, 1855.

Composition of Manure in Natural State.

Water		73·90
*Soluble organic matter		2·70
Soluble inorganic matter (ash):—		
Soluble silica	·147	
Phosphate of lime	·129	
Lime	·018	
Carry forward		76·60

Brought forward		76·60
Magnesia	·018	
Potash	·960	
Soda	·082	
Chloride of sodium	·052	
Sulphuric acid	·072	
Carbonic acid and loss	·584	
		2·06
†Insoluble organic matter		14·39
Insoluble inorganic matter (ash):—		
Soluble silica	1·10	
Insoluble silica	1·54	
Oxide of iron and alumina, with phosphates ..	0·37	
Containing phosphoric acid	(·06)	
Equal to bone earth	(·10)	
Lime	2·25	
Magnesia	·02	
Potash	·12	
Soda	·01	
Sulphuric acid	·10	
Carbonic acid and loss	1·44	
		6·95
		100·00

* Containing nitrogen	·149
Equal to ammonia	·180
† Containing nitrogen	·061
Equal to ammonia	·074
Whole manure contains ammonia in free state	·015
,, ,, in form of salts	·048

Well-rotten Farmyard Manure (No. IV.), *Exposed.*

Analysis made Feb. 14, 1855.

Composition of Manure in Dry State.

*Soluble organic matter		10·34
Soluble inorganic matter (ash):—		
Soluble silica	·564	
Phosphate of lime	·493	
Lime	·067	
Magnesia	·068	
Potash	3·680	
Soda	·321	
Chloride of sodium	·194	
Sulphuric acid	·278	
Carbonic acid and loss	2·225	
		7·89
†Insoluble organic matter		55·13
Insoluble inorganic matter:—		
Soluble silica	4·24	
Insoluble silica	5·91	
Oxide of iron and alumina, with phosphates	1·41	
Containing phosphoric acid	(·24)	
Carry forward		73·36

Brought forward		73·36
Equal to bone earth	(·38)	
Lime	7·65	
Magnesia	·08	
Potash	·45	
Soda	·06	
Sulphuric acid	·38	
Carbonic acid and loss	6·46	
		26·64
		100·00

* Containing nitrogen	·57
Equal to ammonia	·69
† Containing nitrogen	2·35
Equal to ammonia	2·85
Whole manure contains ammonia in free state ..	·57
" " in form of salts	·183

Composition of Ash of Portion soluble in Water of same Manure.

Soluble silica	7·15
Phosphate of lime	6·25
Lime	·86
Magnesia	·87
Potash..	46·65
Soda	4·07
Chloride of sodium	2·47
Sulphuric acid	3·52
Carbonic acid and loss	28·16
	100·00

Composition of Ash of Portion insoluble in Water of same Manure.

Soluble silica	15·93
Insoluble silica	22·20
Oxides of iron and alumina, with phosphates	5·30
Containing phosphoric acid	(·93)
Equal to bone earth	(1·45
Lime	32·48
Magnesia	·30
Potash	1·70
Soda	·23
Sulphuric acid	1·42
Carbonic acid and loss	20·44
	100·00

Well-rotten Farmyard Manure.

Analysis made Feb. 14, 1855.

Composition of whole Ash.

Soluble in water, 22·85 per cent.	Soluble silica	1·63
	Phosphate of lime	1·43
	Lime	·19
	Magnesia	·20
	Potash	10·66
	Soda	·93
	Chloride of sodium	·56
	Sulphuric acid	·80
	Carbonic acid and loss	6·45

			Arranged together.
Insoluble in water, 77·15 per cent.	Soluble silica	12·13	13·76
	Insoluble silicious matter (sand)	17·12	17·12
	Phosphate of lime	..	1·43
	Oxides of iron, alumina, with phosphates	4·08	4·08
	Containing phosphoric acid	(·71)	(·71)
	Equal to bone earth	(1·11)	(1·11)
	Lime	25·05	25·24
	Magnesia	·23	·43
	Potash	1·31	11·97
	Soda	·17	1·10
	Chloride of sodium	..	·56
	Sulphuric acid	1·09	1·89
	Carbonic acid and loss	15·97	22·41
		100·00	100·00

A glance at these analytical results will show that the proportion of soluble organic matters in the well-rotten dung is smaller in February 1855 than in December 1854. It would thus appear that a portion of the soluble constituents has been washed away by rain or melting snow. As the heap was small, it was no doubt more readily affected by this deteriorating cause than a large heap would have been. It is moreover probable that the sample of the manure which was analysed in February did not fairly represent the whole heap. It appears to me therefore very likely that the proportion of soluble matters in the whole heap is in reality larger than is indicated by the foregoing analysis.

It will further be observed that the dry manure in February contains about 2 per cent. less of organic matters than in December. We have thus here a direct proof that the proportion of organic matters decreases in dung-heaps even in the coldest months of the year—it is true in a less considerable degree than in summer, but yet to an appreciable extent.

I would call attention to the manner in which the nitrogen is distributed amongst the constituents of this manure. When just removed from a well-constructed dung-pit in December 1854, 100 lb. of the perfectly dry manure contained 1·21 per cent. of nitrogen in the form of soluble compounds; in February 1855, the soluble portion of the manure contained only ·57 per cent. of nitrogen, thus showing that a portion of the soluble nitrogenized matters has escaped either into the air, or, what is more probable, has been washed out by the rain or melting snow. Notwithstanding this loss in nitrogen, the total percentage of nitrogen has become slightly greater by keeping for 2 months and 9 days.

With respect to the free ammonia, it will be observed that rotten dung contains rather more free ammonia than fresh. The

free ammonia, which under all circumstances constitutes but a small fraction of a per cent. of the manure, however, sinks again in February to a mere trace. Direct experiments, made with a view of ascertaining the cause of this difference, have shown me that farmyard manure gives off no ammonia when quite cold, and that free ammonia can only be disengaged when the dung-heap is in an active state of fermentation, which is always accompanied with evolution of heat. In the interior of large heaps the heat of the dung is often very great, and it is in this part of the heap that ammonia is given off largely. Before, however, it can escape into the air it has to pass a portion of manure which is kept cold by the surrounding air. This external and cold part of dung-heaps acts as a mechanical and chemical filter with reference to the ammonia which is given off from the interior and heated portion of the heap. On account of the porous condition of the litter and partly dried excrements the ammonia is fixed mechanically; but as all organic substances exposed to the atmosphere and moisture are gradually changed into humus, which as we have seen already is an excellent fixer of ammonia, the external parts of dung-heaps may also be called a chemical filter which prevents the loss of ammonia.

Dung-heaps that have been placed in a field, after a short time, when settled down to a firm mass, do not give off any ammonia, but on turning such heaps a very powerful and pungent smell is readily perceptible. Each turning of a manure-heap thus is attended with a certain loss in ammonia, since it escapes from heated manure. It may therefore be advisable not to turn manure-heaps more frequently than is absolutely necessary.

In the preceding pages I have given detailed organic and inorganic analyses of the fresh and the rotten dung in the state in which both were used in the experimental heaps. I have likewise given such analyses of the fresh manure, after it had been kept for 3 months and 11 days in two different ways, and of the rotten dung after having been exposed to the weather for 2 months and 9 days.

Another detailed analysis of the fresh manure, after having been spread out in an open yard for a period of 6 months, will be found in the succeeding pages. The various experimental heaps were weighed for the second time on the 30th of April, 1855, and at the same time samples for analysis taken from each heap.

The two heaps made on the 3rd of November, 1855, with fresh mixed farmyard manure and the portion of fresh dung spread out in an open yard, thus were kept for 6 months, minus 3 days; whilst the rotten dung, being placed in a heap on the 5th of December, was kept for only 5 months, minus 5 days. The loss in weight having been ascertained in each case, the

manure was carted back in its former place and kept under the same respective circumstances until the 23rd of August, 1855, when again each experimental portion was weighed separately and again analysed.

The rotten dung thus had been kept by the 23rd of August for a period of 8 months and 18 days, the rest of the experimental manure heaps for a period of 9 months 20 days.

Finally the different experimental heaps were weighed and analysed for the last time on the 15th of November, 1855. The rotten dung thus had been exposed to the influence of the atmosphere for a period of 11 months and 10 days, and the 3 remaining experimental portions of originally fresh dung had been kept for a period of 12 months and 12 days.

In order to render more conspicuous the results obtained in the direct weighings and in the different analyses, I shall incorporate them in separate Tables, which will be given under the respective heads of

1. Fresh farmyard manure, (No. I.) Exposed.
2. .. .. .. (No. II.) Under shed.
3. .. .. .. (No. III.) Spread.
4. Well-rotten farmyard manure, (No. IV.) Exposed.

Before stating these details I may say that I have taken especial care in determining accurately the nitrogen in each series of analyses. Frequently two combustions were made of one and the same substance, and invariably closely agreeing results obtained.

Fresh Farmyard Manure (No. I.), *Exposed* (mixed horse, cow, and pig dung).

In the subjoined Table is stated the actual weight of the first experimental heap at different periods of the year, and the loss which it sustained in these periods.

Table showing the Weight of Experimental Heap of Fresh Farmyard Manure (No. I.), Exposed, at different periods, and Percentage of Loss in Weight, expressed in lbs.

	Weight of Manure in lbs.	Loss in Original Weight in lbs.	Percentage of Loss.
Put up on the 3rd of November, 1854	2838	—	—
Weighed on the 30th of April, 1855, or after a lapse of 6 months	2026	812	28·6
Weighed on the 23rd of August, 1855, or after a lapse of 9 months and 20 days	1994	844	29·7
Weighed on the 15th of November, 1855, or after a lapse of 12 months, and 12 days ..	1974	864	30·4

In the course of a year and 12 days the original weight of this heap, amounting to 1 ton 5 cwts. 1 quarter and 10 lbs. thus became reduced to 17 cwts. 2 quarters and 14 lbs. by being exposed to the influence of the weather, or 100 tons lost 30·4 tons.

We shall see presently in what this loss consisted. I may mention, however, already in this place that the direct weighings do not represent in an unmistakable manner the loss which farmyard manure undergoes in reality in keeping. We shall see, namely, that the loss during the last 3 months is much greater than stated in the foregoing Table, after we shall have become acquainted with the composition, which the manure presented at the different periods, when it was weighed.

In the first place I would therefore direct the attention of the reader to the following Table, in which is given the composition of the manure in the state in which it was found at the different experimental weighings.

Composition of Fresh Farmyard Manure (No. I.), Exposed in Natural State, at different periods of the Year.

	When put up on the 3rd Nov. 1854.	Feb. 14th, 1855.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
Water	66·17	69·83	65·95	75·49	74·29
*Soluble organic matters ..	2·48	3·86	4·27	2·95	2·74
Soluble inorganic matters ..	1·54	2·97	2·86	1·97	1·87
†Insoluble organic matters ..	25·76	18·44	19·23	12·20	10·89
Insoluble mineral matters ..	4·05	4·90	7·69	7·39	10·21
	100·00	100·00	100·00	100·00	100·00
*Containing nitrogen	·149	·27	·30	·19	·18
Equal to ammonia	·181	·32	·36	·23	·21
†Containing nitrogen	·494	·47	·59	·47	·47
Equal to ammonia	·599	·57	·71	·62	·57
Total amount of nitrogen ..	·643	·74	·89	·66	·65
Equal to ammonia	·780	·89	1·07	·85	·78
Ammonia in a free state ..	·034	·019	·008	·010	·006
Ammonia in form of salts, easily decomposed by quicklime	·088	·064	·085	·038	·041
Total amount of organic matters	28·24	22·30	23·50	15·15	13·63
Total amount of mineral substances	5·59	7·87	10·55	9·36	12·08

It will be seen that in February this manure contained about 3½ per cent. more moisture than when first put up. At the end of April, little or no rain having fallen in the interval, it dried up to its original state of dryness. The loss in weight in April

amounting to 28·6 per cent., therefore, is real loss, that is to say it is loss which affects the dry manure, and is not due to evaporation of water. In other words 100 lbs. of dry manure, on keeping for a period of 6 months exposed to the weather, lost 28·6 lbs., and became only 71·4 lbs. In August the manure gained a very large quantity of water, by heavy showers of rain, and this large proportion of water, which is greater than the original quantity of moisture by nearly 10 per cent., was reduced only 1 per cent. on keeping of the manure for another 3 months.

The direct-weighings, as well as the composition of the manure, are therefore much affected by the rain that falls at the different periods, and for this reason, neither the analyses nor the weighings by themselves are fit to determine the loss which farmyard-manure undergoes on keeping.

Before any further remarks can be offered on these analyses it will be necessary to calculate the composition of the manure in a dry state, for as the percentage of water differs so much at the various times of analysis, the results in the preceding Table are not comparable. In the next Table, therefore, I have stated the composition of the perfectly dry manure at various epochs.

Composition of Fresh Farmyard Manure (No. I.), Exposed. Calculated Dry.

	When put up. Nov. 3rd, 1854.	Feb. 14th, 1855.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
*Soluble organic matters	7·33	12·79	12·54	12·04	10·65
Soluble inorganic matters ..	4·55	9·84	8·39	8·03	7·27
†Insoluble organic matters ..	76.15	61·12	56·49	49·77	42·35
Insoluble mineral matters ..	11·97	16·25	22·58	30·16	39·73
	100·00	100·00	100·00	100·00	100·00
*Containing nitrogen	·44	·91	·88	·77	·72
Equal to ammonia	·53	1·10	1·06	·93	·88
†Containing nitrogen	1·46	1·55	1·75	1·92	1·85
Equal to ammonia	1·77	1·88	2·12	2·33	2·24
Total amount of nitrogen ..	1·90	2·46	2·63	2·69	2·57
Equal to ammonia	2·30	2·98	3·18	3·26	3·12
Ammonia in free state	·10	·062	·023	·041	·023
Ammonia in form of salts, easily decomposed by quicklime ..	·26	·212	·249	·154	·159
Total amount of organic matters	83·48	73·91	69·03	61·81	53·00
Total amount of mineral substances	16·52	26·09	30·97	38·19	47·00

A comparison of these different analyses points out clearly the changes which fresh farmyard manure undergoes on keeping in a heap, exposed to the influence of the weather during a period of twelve months and twelve days.

1. It will be perceived that the proportion of organic matter steadily diminishes from month to month, until the original percentage of organic matter in the dry manure, amounting to 83·48 per cent., became reduced to 53 per cent.

2. On the other hand, the total percentage of mineral matters rises as steadily as that of the organic matters falls.

3. It will be seen that the loss in organic matters affects the percentage of insoluble organic matters more than the percentage of soluble organic substances.

4. The percentage of soluble organic matters indeed increased considerably during the first experimental period; it rose, namely, from 7·33 per cent. to 12·79 per cent. Examined again on the 30th of April, very nearly the same percentage of soluble organic matters as on February the 14th was found. The August analysis shows but a slight decrease in the percentage of soluble organic matters, whilst there is a decrease of 2 per cent. of soluble organic matters when the November analysis is compared with the February analysis.

5. The soluble mineral matters in this manure rise or fall in the different experimental periods in the same order as the soluble organic matters. Thus, in February, 9·84 per cent. of soluble mineral matters were found, whilst the manure contained only 4·55 per cent., when put up into a heap in November, 1854. Gradually, however, the proportion of soluble mineral matters again diminished, and became reduced to 7·27 per cent., on the examination of the manure in November, 1855.

6. A similar regularity will be observed in the percentage of nitrogen contained in the soluble organic matters.

7. In the insoluble organic matters the percentage of nitrogen regularly increased from November, 1854, up to the 23rd of August, notwithstanding the rapid diminution of the percentage of insoluble organic matters. For the last experimental period the percentage of nitrogen in the insoluble matters is nearly the same as in August 23rd.

8. With respect to the total percentage of nitrogen in the fresh manure, examined at different periods of the year, it will be seen that the February manure contains about one-half per cent. more of nitrogen than the manure in a perfectly fresh state. On the 30th of April the percentage of nitrogen again slightly increased; on August 23rd it remained stationary, and had sunk but very little when last examined on the 15th of November, 1855.

This series of analyses thus shows that fresh farmyard manure rapidly becomes more soluble in water, but that this desirable change is realised at the expense of a large proportion of organic matters. It likewise proves in an unmistakable manner that there is no advantage in keeping farmyard manure for too long

a period; for after February neither the percentage of soluble organic nor that of soluble mineral matters has become greater; and the percentage of nitrogen in the manure of April and August is only a very little higher than in February.

Weight for weight, the February manure thus will be as good as the manure in April or August, and slightly superior to the manure in November, 1855. The direct weighings, however, of the whole heap have shown us already that a considerable loss in weight is experienced in the different periods during which the manure was kept. And as the fresh manure did not improve in composition after the 14th of February, it is clear that the loss in weight is not due to the mere evaporation of water or the dissipation of other useless constituents, but is a real loss in valuable fertilising constituents.

That this is really the case appears still more decidedly if we consult the direct weighings of the experimental heap, and the composition of the manure at the time at which the weighings were made. This will enable us to calculate the composition of the whole heap at the different experimental periods, and we shall then see in what manner the loss in weight is distributed amongst the various constituents of the manure.

In the following Table the composition which the whole experimental heap, No. I., exhibited at different periods of the year, has been calculated from data already given. The actual weight of the manure heaps is again stated in the first horizontal column; in the second horizontal column, the actual amount of water in the whole heap is stated; and in the third, the total amount of dry matter. The next four (bracketed together) show the composition of the dry matter. All numbers in the Table express pounds or fractions of pounds.

A careful study of the Table will convince the reader that the real loss in valuable fertilising matters which farmyard manure sustains in keeping is very much greater than is indicated by the direct weighings of the experimental heap. It will be remembered that the manure, when put up in a heap on the 3rd of November, 1854, contained 66·17 per cent. of water, and consequently 33·83 per cent. of dry matters. The total amount of dry matter in the perfectly fresh experimental heap amounted to 960·10 lbs.; but, after having been exposed to the influence of the weather for a period of nine months, only 488·7 lbs. of dry substance are left behind. The direct weighing of the heap in August indicates a loss of 29·77 per cent., whereas in reality a loss of very nearly 50 per cent. in the solid constituents of the manure has been incurred. This *enormous waste* in manuring matters, it will appear likewise from a careful perusal of the Table, may be prevented, at least to a very great ex-

tent, by applying either the manure in a fresh state to the land, or, if this is inadmissible, by keeping it no longer than is absolutely necessary.

Table showing Composition of the Whole Heap: Fresh Farmyard Manure (No. I.), Exposed. Expressed in lbs.

	When put up. Nov. 3rd, 1854.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
Weight of manure in lbs.	2838	2026	1994	1974
Amount of water in the manure	1877·9	1336·1	1505·3	1466·5
Amount of dry matter in the manure ..	960·1	689·9	488·7	507·5
Consisting of—				
*Soluble organic matter	70·38	86·51	58·83	54·04
Soluble mineral matter	43·71	57·88	39·16	36·89
†Insoluble organic matters	731·07	389·74	243·22	214·92
Insoluble mineral matter	114·94	155·77	147·49	201·65
	960·1	689·9	488·7	507·5
*Containing nitrogen	4·22	6·07	3·76	3·65
Equal to ammonia	5·12	7·37	4·56	4·36
†Containing nitrogen	14·01	12·07	9·38	9·38
Equal to ammonia	17·02	14·65	11·40	11·39
Total amount of nitrogen in manure ..	18·23	18·14	13·14	13·03
Equal to ammonia	22·14	22·02	15·96	15·75
The manure contains ammonia in free state	·96	·15	·20	·11
,, ,, ammonia in form of salts, easily decomposed by quicklime	2·49	1·71	·75	·80
Total amount of organic matters	801·45	476·25	302·05	268·96
Total amount of mineral matters	158·15	213·65	186·65	238·54

It will be remarked that in the first experimental period the fermentation of the dung, as might have been expected, proceeded most rapidly, but that, notwithstanding, very little nitrogen was dissipated in the form of volatile ammonia; and that on the whole the loss which the manure sustained was inconsiderable when compared with the enormous waste to which it was subject in the subsequent warmer and more rainy seasons of the year. Thus we find at the end of April very nearly the same amount of nitrogen which is contained in the fresh; whereas, at the end of August, 27·9 per cent. of the total amount of nitrogen, or nearly one-third of the nitrogen in the manure, has been wasted in one way or the other.

It is worthy of observation that, during a well-regulated fermentation of dung, the loss in intrinsically valuable constituents is inconsiderable, and that in such a preparatory process the efficacy of the manure becomes greatly enhanced. For certain purposes fresh dung can never take the place of well-rotten dung.

The farmer will, therefore, always be compelled to submit a portion of home-made dung to fermentation, and will find satisfaction in knowing that this process, when well regulated, is not attended with any serious depreciation of the value of the manure. In the foregoing analyses he will find the direct proof that, as long as heavy showers of rain are excluded from manure heaps, or the manure is kept in waterproof pits, the most valuable fertilising matters are preserved. But let us now see how matters stand when manure heaps, the component parts of which have become much more soluble than they were originally, are exposed to heavy showers of rain.

In the first experimental period little rain fell, and this never in large quantities at a time, whilst in the interval of April and August rain was more abundant, and fell several times in continuous heavy showers. In consequence of this the soluble matters in the heap have been washed out, and with them a considerable portion of available nitrogen, and the more valuable mineral constituents of dung have been wasted.

The above analytical data, if I am not mistaken, afford likewise a proof that even in active fermentation of dung little nitrogen escapes in the form of volatile ammonia, but that this most valuable of all fertilising materials, along with others of much agricultural importance, is washed out in considerable quantities by the rain which falls on the heaps and is wasted chiefly in the drainings of the dungheaps.

A single fact, it has been truly said, is worth more than a dozen vague speculations. We hear frequently people talk of the loss in ammonia which farmyard manure undergoes on keeping, and this loss is referred by them to the volatilization of the ammonia which is produced in the putrefaction of the nitrogenized constituents of dung. I have, however, already mentioned that simultaneously with the ammonia, ulmic, humic, and other organic acids are generated from the non-nitrogenized constituents of manure, and that these acids possess the power of fixing the ammonia in an excellent manner. If this were not the case it would be difficult, if not impossible, to explain the circumstance that the proportion of soluble nitrogenized matters increased considerably in the manure on keeping for a period of six months, and that during this period the total amount of nitrogen scarcely suffered any diminution. In April the amount of nitrogen in the soluble matters of the entire heap is 6·07 lbs., and by the 23rd of August it is reduced to 3·76 lbs. Why, it may be asked, is it not likely that most of this nitrogen has passed into the air in the form of volatile ammoniacal compounds? In reply to this question I would answer that a loss taking place in this way would be felt

much more sensibly in the period of active fermentation, in which, however, we have seen that scarcely any nitrogen is dissipated. In the August and November analyses, moreover, it will be observed that not only the amount of soluble organic matters, and with it that of the nitrogen, decreases, but that the soluble mineral matters, which in April amount to 57·88 lbs. in the entire heap, became reduced to 39·16 lbs. by the 23rd of August. Now, this decrease in soluble mineral substances can only be ascribed to the rain which fell in this period, and it is plain that the deteriorating influence of heavy showers of rain must equally affect the soluble nitrogenized constituents of dung. That this is really the case will appear still more conspicuously by the analysis of experimental heap No. III., to be mentioned hereafter.

It may perhaps appear strange to the reader that the total amount of dry matter in the manure is greater in November, 1855, than in August, and likewise that there is a good deal more insoluble mineral matter at the end of the experimental year than at the beginning. In explanation of these apparent inconsistencies, I would observe that the increase in insoluble mineral matters is accounted for in the difficulty of shovelling the manure into the dung-cart without mixing with it each time the weighing is made a certain portion of the soil on which the heap is placed. It must likewise be borne in mind that it is almost next to impossible to incorporate mechanical impurities so thoroughly with the dung that differences amounting to 2 or 3 per cent. in the amount of insoluble matters may not occur in the analyses of 2 samples taken from the same heap. In the percentic composition of farmyard manure such differences appear inconsiderable, but when applied to the whole heap they strike us as being great. In short, it is impossible to determine accurately the total amount of insoluble mineral matters in the whole heap. The general deductions, however, which may legitimately be made from the foregoing analyses are not in any perceptible degree affected by this unavoidable source of inaccuracy; but it is well to remember not to dwell too much on minor differences which perhaps may strike the reader; some such differences may be due to purely accidental causes.

Before I pass over to the experimental heap No. II., I would direct attention to the subjoined Table, in which I have calculated the loss or gain which the experimental heap No. I. sustained in the different constituents in the course of the year. Where there is a gain the sign * is prefixed to the number to which it applies; all numbers without this sign express loss in lbs. and in fractions of lbs. The loss for the whole heap has been calculated for 100 lbs. of fresh manure, as well as per ton.

In the columns headed per cent. thus may be seen how much of each of the constituents of fresh dung is lost by 100 lbs., cwts., or tons, in the course of 6, 9, or 12 months; whilst the columns headed loss per ton, give the loss in lbs. for every ton of fresh farmyard manure.

Table showing Loss in the different constituents of Experimental Heap, No. I., at different Periods of the Year; likewise Percentage of Loss and Loss per Ton of Fresh Manure. (N.B. The numbers preceded by the sign * express Gain and not Loss.)

	From November 3, 1854,								
	To April 30, 1855. Kept 6 Months.			To August 23, 1855. Kept 9 Months.			To November 15, 1855. Kept 12 Months.		
Loss in weight of—		Per cent.	Per ton.		Per cent.	Per ton.		Per cent.	Per ton.
Entire heap	812·	28·61	640·86	844·	29·77	666·84	864·	30·45	682·07
Water	541·8	19·09	427·62	372·6	13·12	239·88	411·4	14·49	324·57
Soluble organic matter	*16·13	*·56	*12·54	11·45	·40	8·96	16·34	·57	12·76
Soluble mineral matter	*14·17	*·49	*10·97	4·55	·16	3·58	6·82	·24	5·37
Insoluble organic matter	341·33	12·03	269·47	487·85	17·18	384·83	516·15	18·17	407·00
Insoluble mineral matter	*40·83	*1·43	*32·08	*32·55	*1·14	*25·53	*86·71	*3·05	*68·32
Containing nitrogen	*1·86	*·065	*1·456	·46	·016	·358	·57	·020	·448
Equal to ammonia	*2·25	*·079	*1·769	·56	·019	·425	·76	·026	·582
Containing nitrogen	1·94	·068	1·523	4·63	·160	3·58	4·63	·160	3·584
Equal to ammonia	2·37	·083	1·859	5·62	·19	4·25	5·63	·19	4·25
Total amount of nitrogen	·09	·003	·067	5·09	1·79	4·099	5·20	·18	4·03
Equal to ammonia	·12	·004	·089	6·18	·21	4·70	6·39	·22	4·92
Ammonia in free state	·81	·028	·627	·76	·026	·582	8·5	·029	·649
Ammonia in form of salts	·78	·027	·604	1·74	·06	1·34	1·69	·059	1·321
Total amount of organic matter	325·20	11·45	256·48	499·40	17·59	394·01	532·49	18·76	420·22
Total amount of mineral matter	*55·00	*1·92	*43·00	*28·00	*·99	*21·95	*79·89	*2·81	*62·94

Experimental Heap (No. II.), *Fresh Farmyard Manure under Shed.*—Horse, cow, and pig dung mixed.

The direct weighings were made on the same days on which the weighings of the heap exposed to the influence of the weather were executed.

The following Table contains the results of these weighings:—

Table showing the actual Weighings, and Percentage of Loss in Weight, of Experimental Heap (No. II.), fresh Farmyard Manure under Shed, at different periods of the Year.

	Weight of Manure in lbs.	Loss in Original Weight in lbs.	Percentage of Loss.
Put up on the 3rd of November, 1854 ..	3258	..	..
Weighed on the 30th of April, 1855, or after a lapse of 6 months	1613	1645	50·4
Weighed on the 23rd of August, 1855, or after a lapse of 9 months and 20 days ..	1297	1961	60·0
Weighed on the 15th of November, 1855, or after a lapse of 12 months and 12 days ..	1235	2023	62·1

Apparently the loss which the heap under shed sustained is much greater than the loss which was incurred by keeping a heap of fresh farmyard manure exposed to the influence of the weather for the same length of time. It will be seen, however, by the following analyses, that this greater loss is principally due to the evaporation of water, which, not being replaced by falling rain, is especially marked in the warmer months of the year.

This will appear from the following Table, containing the results of analyses made at the fixed experimental periods.

Table showing the Composition of Experimental Heap (No. II.), fresh Farmyard Manure under Shed, in natural state, at different periods of the Year.

	When put up. Nov. 3rd, 1854.	Feb. 14th, 1855.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
Water	66·17	67·32	56·89	43·43	41·66
*Soluble organic matters	2·48	2·63	4·63	4·13	5·37
Soluble inorganic matters ..	1·54	2·12	3·38	3·05	4·43
†Insoluble organic matters [1] ..	25·76	20·46	25·43	26·01	27·69
Insoluble mineral matters ..	4·05	7·47	9·67	23·38	20·85
	100·00	100·00	100·00	100·00	100·00
*Containing nitrogen	·149	·17	·27	·26	·42
Equal to ammonia	·181	·20	·32	·31	·51
†Containing nitrogen	·494	·58	·92	1·01	1·09
Equal to ammonia	·599	·70	1·11	1·23	1·31
Total amount of nitrogen ..	·643	·75	1·19	1·27	1·51
Equal to ammonia	·780	·90	1·43	1·54	1·82
Ammonia in free state	·034	·022	·055	·015	·019
Ammonia in form of salts, easily decomposed by quicklime ..	·088	·054	·101	·103	.146
Total amount of organic matters	28·24	23·09	30·06	30·14	33·06
Total amount of mineral substances	5·59	9·59	13·05	26·43	25·28

As these analytical results do not admit of comparison on account of the great variations in the amount of moisture contained in this manure at different periods, the composition of the manure in a perfectly dry state may at once be stated. (See Table, p. 237.)

These analytical results give rise to the following observations:—

1. It will be seen that the percentage of organic matter in this manure steadily diminishes the longer the manure is kept, whilst the percentage of mineral matters rises in a corresponding degree.

2. The decrease in organic substances, however, is much less considerable than in the heap No. I., which had been exposed to the influence of the weather.

3. It will likewise be observed that the percentage of soluble

Table showing the Composition of Experimental Heap (No. II.), fresh Farmyard Manure under Shed, calculated dry, at different periods of the Year.

	When put up. Nov. 3rd, 1854.	Feb. 14th, 1855.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
*Soluble organic matters	7·33	8·04	10·74	7·30	9·20
Soluble inorganic matters ..	4·55	6·48	7·84	5·39	7·59
†Insoluble organic matters ..	76·15	62·60	58·99	45·97	47·46
Insoluble mineral matters ..	11·97	22·88	22·43	41·34	35·75
	100·00	100·00	100·00	100·00	100·00
*Containing nitrogen	·44	·53	·63	·46	·72
Equal to ammonia	·53	·66	·76	·56	·88
†Containing nitrogen	1·46	1·77	2·14	1·78	1·88
Equal to ammonia	1·77	2·14	2·59	2·16	2·20
Total amount of nitrogen ..	1·90	2·30	2·77	2·24	2·60
Equal to ammonia	2·30	2·80	3·35	2·72	3·08
Ammonia in free state	·10	·067	·127	·026	·032
Ammonia in form of salts, easily decomposed by quicklime ..	·26	·165	·234	·182	·250
Total amount of organic matters	83·48	70·64	69·73	53·27	56·66
Total amount of mineral substances	16·52	29·36	30·27	46·73	43·34

organic and mineral substances increases, up to the 30th of April, with the time during which the heap has been kept under shed; but that this increase is not so great as in the experimental heap No. I.

4. The proportion of free ammonia, and of ammonia contained in salts which are readily decomposed by quicklime, perceptibly decreases on keeping of the manure.

5. The total amount of nitrogen, on the contrary, perceptibly increases in the several experimental periods.

6. The amount of nitrogen in the soluble organic matters slightly, but regularly, increases with the time during which the manure is kept; and the same remark applies to the nitrogen in the insoluble organic matters.

7. The August analysis exhibits a very much larger percentage of insoluble inorganic substances than the April analysis, and even than the analysis made on the 15th of November, 1855.

It is evident that the sample taken for analysis on the 23rd of August contained a considerable amount of mechanical impurities, which spoil, to some extent, the general results. In a minor degree this source of error will be perceived in the November analysis (November 15th, 1855). If, however, due allowance be made for this evident admixture of accidental earthy matters,

the analysis made in August and in November, 1855, will be found to correspond perfectly in their general bearings with the other analyses. Having obtained the results by carefully executed analyses, I did not feel justified in introducing corrections, even in case such corrections seemed desirable to be made. A critical mind will derive from the two last analyses as much instruction as from the three preceding. They afford, at the same time, a direct proof of the necessity of not being satisfied with one or two analyses in researches of this kind, and show that trustworthy deductions can be derived only from a series of carefully conducted analyses. It is too often the case that corrections are introduced into analyses which cannot always be referred to plain and evident disturbing causes; and as such a course, if tolerated, opens at once the door to abuse, I have ever set my face against such a practice, and therefore prefer to state my results as I get them, whether or not they agree with others.

The preceding analyses furnish plain evidence that the constituents of the manure under shed have become far less altered in composition than in the case of the experimental heap No. II. And, indeed, the physical condition of the heap under shed affords a convincing proof of the fact that fresh farmyard manure does not properly ferment when it is kept under cover, and the water, which constantly evaporates from its surface, is not replaced by pumping occasionally water or liquid manure over the heap.

The fermentation, however, of the dung cannot be entirely prevented by this mode of treatment. As might have been expected, fermentation is more perceptible in the first experimental periods than in the succeeding. By the time the percentage of water in this manure had become reduced to 56 per cent., practically speaking a stop was put to further fermentation, and the manure remained very much in the same condition, at the end of the experimental year, in which it was found at the end of April.

In the next Table the composition of the whole heap under shed, as calculated from the preceding analyses, is given (p. 239).

A reference to the Table will show that the loss incurred in keeping of fresh farmyard manure under cover is greatest in the first experimental period, and that this loss principally affects the insoluble organic matter. Thus, when put under cover, the whole heap contained, in round numbers, 839 lbs. of insoluble organic substances, whilst after a lapse of six months only 410 lbs. were left over. One half of the total amount of insoluble organic matters thus has been dissipated, in the form of carbonic acid and other gaseous products of decomposition, in the course

Table showing Composition of entire Experimental Heap (No. II.), fresh Farmyard Manure, under Shed.

	When put up. Nov. 3rd, 1854.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
Weight of manure	3258	1613	1297	1235
Amount of water in the manure	2156·	917·6	563·2	514·5
Amount of dry matter	1102·	695·4	733·8	720·5
Consisting of—				
*Soluble organic matter	80·77	74·68	53·56	66·28
Soluble mineral matter	50·14	54·51	39·55	54·68
†Insoluble organic matter	839·17	410·24	337·32	341·97
Insoluble mineral matter	131·92	155·97	303·37	257·57
	1102·	695·4	733·8	720·5
*Containing nitrogen	4·85	4·38	3·46	5·25
Equal to ammonia	5·88	5·33	4·20	6·37
†Containing nitrogen	16·08	14·88	13·08	13·54
Equal to ammonia	19·52	17·46	15·88	16·44
Total amount of nitrogen in manure ..	20·93	19·26	16·54	18·79
Equal to ammonia	25·40	22·79	20·08	22·81
The manure contains ammonia in free state	1·10	·88	·19	·23
,, ,, ammonia in form of salts, easily decomposed by quicklime	2·86	1·62	1·33	1·80
Total amount of organic matters	919·94	484·92	390·88	408·25
Total amount of mineral matters	182·06	210·48	342·92	312·85

of six months. Or, calculating the loss in dry matter, for the whole manure-heap in a dry state, we find that 100 parts of the dry manure have lost, under cover, about 37 per cent. in solid matters. The dissipation of organic matter is not attended with any great loss in nitrogen, for it will be observed that the entire heap contained in November, 1854, when first put up, 20·93 lbs. of nitrogen, and on the 30th of April, 19·26 lbs.; consequently, about 1½ lb. of nitrogen only escaped, in one way or the other, during this period.

It would appear that this inconsiderable amount of nitrogen escaped by evaporation, in the form of volatile carbonate of ammonia; for the differences exhibited by the November and April analyses, in the proportion of free ammonia and ammonia in form of salts readily decomposed by quicklime, very nearly correspond with a loss of about 1½ lb. of nitrogen.

Perhaps it may appear strange that the manure-heap No. I., which was exposed to the weather, lost less nitrogen, in the form of ammonia, during the first six months than the heap under cover. But this apparent anomaly finds a ready explana-

tion in the fact that during an active fermentation organic acids are formed which fix the ammonia, while the same acids are not so readily produced in the absence of the requisite amount of moisture.

At the same time it should be borne in mind that ammonia escapes more readily from a partially-dried substance than one saturated with moisture; and as the manure-heap under shed on keeping became much drier than the heap exposed to the weather, the free ammonia had a better chance of being dissipated into the air.

The August and November, 1855, analyses on account of the accidental impurities, do not give a fair representation of the changes which may have taken place during these periods.

There should be of course the same total amount of mineral matters at the end of the experimental year which occurs in the manure when first placed under cover. Omitting the fractions we have in November, 1855, 182 lbs. of mineral matters, and on the 30th of April, 210 lbs., or a difference which is not greater than might have been expected in two analyses of the same sample of manure.

But assuming the samples, which have been taken for the August and November analyses, to represent fairly the composition of the whole heap, we would have no less than 343 lbs. of mineral matters in August, and 312 lbs. the following November. Now this cannot be the case, and it is therefore plain that the excess of mineral matters must be due to accidental admixture of dirt to the dung. Such an admixture of course will reduce the amount of nitrogen and organic matters in the analyses: but if a correction be made for this palpable inaccuracy it will be found that after the 30th of April the heap under shed sustained but a very trifling loss in nitrogen and organic matters.

Leaving the reader to make this calculation for himself, I append a Table which will furnish the data for similar calculations (p. 241).

Experimental Heap (No. III.), *fresh Farmyard Manure, spread in an open Yard.*—Mixed horse, cow, and pig dung.

Having furnished the reader with a complete analysis of each experimental heap with the exception of the manure spread out in an open yard, I thought it desirable to submit the manure No. III., the originally fresh farmyard manure, to a complete organic and inorganic analysis, after it had been exposed to the influence of rain, sun, and wind for a period of six months. The results of this examination are incorporated in the following Tables.

Table showing Loss in the different component parts of Experimental Heap, No. II., at different periods of the Year; likewise Percentage of Loss and Loss per Ton of Fresh Manure.

(N.B. The numbers preceded by the sign * express Gain instead of Loss.)

	From November 3, 1854,								
	To April 30, 1855. Kept 6 Months.			To August 28, 1855. Kept 9 Months.			November 15, 1855. Kept 12 Months.		
Loss in weight of—		Per cent.	Per ton.		Per cent.	Per ton.		Per cent.	Per ton.
Entire heap	1645·	50·49	1130·97	1961·	60·19	1348·25	2023·	62·09	1390·81
Water	1238·4	38·	851·20	1592·8	48·88	1094·91	1641·5	50·35	1127·84
*Soluble organic matter	6·09	·18	4·03	27·21	·83	18·59	14·46	·44	9·85
Soluble mineral matter	*4·37	*·13	*2·91	10·59	·32	7·16	*4·54	*·14	*3·13
†Insoluble organic matter	428·93	13·16	294·78	501·85	15·40	344·96	497·2	15·26	341·82
Insoluble mineral matter	*24·05	*·73	*16·35	*171·45	*5·26	*117·82	*125·65	*3·85	*86·24
*Containing nitrogen	·47	·014	·31	1·39	·042	·94	*·40	*·012	*·26
Equal to ammonia	·55	·016	·35	1·68	·051	1·14	*·49	*·015	*35
†Containing nitrogen	1·20	·036	80	3·00	·092	2·06	2·54	·078	1·74
Equal to ammonia	2·06	·063	1·41	3·64	·111	2·48	3·08	·094	2·10
Total amount of nitrogen	1·67	·051	1·14	4·39	·134	3·00	2·14	·065	1·45
Equal to ammonia	2·61	·080	1·79	5·32	·163	3·65	2·59	·079	1·76
Ammonia in free state	·22	·006	·13	·91	·027	·60	·87	·026	·58
Ditto in form of salts	1·24	·03	·67	1·53	·046	1·03	1·06	·032	·71
Total amount of organic matter	435·02	13·34	298·81	529·06	16·23	363·55	511·69	15·70	351·67
Ditto mineral matter	*28·42	*86	*19·25	*160·86	*4·94	*110·66	*130·19	*3·99	*89·37

Fresh Farmyard Manure (No. III.), *Spread in open Yard.*

Taken for Analysis, April 30, 1855.

(a.) *Composition of Manure in Natural State.*

Water		80·02
* Soluble organic matter		1·16
Soluble inorganic matter (ash) :—		
Soluble silica	·211	
Phosphate of lime	·194	
Lime	·005	
Magnesia	·008	
Potash	·365	
Soda	·037	
Chloride of sodium	·004	
Sulphuric acid	·041	
Carbonic acid and loss	·145	
		1·01
† Insoluble organic matter		11·46
Insoluble inorganic matter :—		
Soluble silica	·955	
Insoluble silicious matter	1·101	
Oxide of iron and alumina, with phosphates ..	·622	
Containing phosphoric acid	(·177)	
Equal to bone earth	(·276)	
Carry forward		93·65

Brought forward		93·65
Lime	1·964	
Magnesia	·082	
Potash	·052	
Soda	·009	
Sulphuric acid	·066	
Carbonic acid and loss	1·499	
		6·35
		100·00

* Containing nitrogen	·08
Equal to ammonia	·09
† Containing nitrogen	·45
Equal to ammonia	·54
Whole manure contains amm. in free state per cent.	·010
" " in form of salts	·045

(*b.*) *Composition of the same Manure in dry state.*

* Soluble organic matter		5·80
Soluble inorganic matter (ash):—		
Soluble silica	1·05	
Phosphate of lime	1·07	
Lime	·02	
Magnesia	·04	
Potash	1·82	
Soda	·18	
Chloride of sodium	·02	
Sulphuric acid	·20	
Carbonic acid and loss	·65	
		5·05
† Insoluble organic matter		57·37
Insoluble inorganic matter (ash):—		
Soluble silica	4·78	
Insoluble silica	5·51	
Oxide of iron and alumina, with phosphates ..	3·11	
Containing phosphoric acid	(·89)	
Equal to bone earth	(1·00)	
Lime	9·83	
Magnesia	·41	
Potash	·27	
Soda	·06	
Sulphuric acid	·33	
Carbonic acid and loss	7·48	
		31·78
		100·00

* Containing nitrogen	·42
Equal to ammonia	·51
† Containing nitrogen	2·28
Equal to ammonia	2·76
Whole manure contains amm. in free state per ct.	·05
" " in form of salts ..	·225

(*c.*) *Composition of Ash of portion insoluble in Water.*

Soluble silica	15·05
Insoluble silicious matter (sand)	17·35
Oxides of iron and alumina, with phosphates	9·80
Containing phosphoric acid	(2·80)
Equal to bone earth	(4·36)
Lime	30·94
Magnesia	1·30
Potash	·87
Soda	·02
Sulphuric acid	1·05
Carbonic acid and loss	23·62
	100·00

Composition of Ash of portion soluble in Water.

Soluble silica	20·93
Phosphate of lime	19·29
Lime	·50
Magnesia	·82
Potash	36·21
Soda	3·69
Chloride of sodium	·41
Sulphuric acid	4·10
Carbonic acid and loss	14·05
	100·00

No. IV. spread out.

Taken for Analysis, April 39, 1855.

Composition of mixed Ash.

			Arranged together.
Soluble in Water, 13·73 per cent.	Soluble silica	2·87	
	Phosphate of lime	2·64	
	Lime	·06	
	Magnesia	·11	
	Potash	4·97	
	Soda	·50	
	Chloride of sodium	·05	
	Sulphuric acid	·50	
	Carbonic acid and loss	2·03	
Insoluble in Water, 86·27 per cent.	Soluble silica	13·05	15·90
	Insoluble silica	14·96	14·96
	Phosphate of lime	..	2·64
	Oxides of iron and alumina with phosphates	8·45	8·45
	Containing phosphoric acid	(2·41)	(2·41)
	Equal to bone earth	(3·76)	(3·76)
	Lime	26·69	26·75
	Magnesia	1·12	1·23
	Potash	·75	5·72
	Chloride of sodium	..	·05
	Soda	·02	·52
	Sulphuric acid	·90	1·40
	Carbonic acid and loss	20·35	22·38
		100·00	100·00

Leaving any remarks on the organic composition of the manure until the general composition at the different experimental periods has been stated, I shall offer in this place merely a few observations on the differences which will be perceived on comparing the ash analyses of the fresh manure with those that have just been given.

1. In the first place it will be seen that the proportion of soluble fresh ash is very much greater in the manure, when the experiment was taken in hand on the 3rd of November, than after a lapse of 6 months, during which the manure was spread out in an open yard and exposed to the deteriorating influence of the weather. Thus we find—

	In fresh Manure, analysed Nov. 3, 1855.	The same Manure, analysed April 30, 1855.
Soluble ash	27·55	13·73
Insoluble ash	72·45	86·27
	100·00	100·00

We have thus here a clear proof that the rain which falls on the manure kept in an open yard, rapidly deteriorates its value by removing from it a very considerable proportion of the most valuable saline constituents.

2. On comparing the insoluble ash of the fresh manure with the corresponding portion of the ash of the manure after having been exposed in an open yard to the weather, it will be seen that there is a much larger proportion of insoluble silicious matter in the April analysis, but less potash and only about half the amount of phosphate of lime which is contained in the insoluble ash of the same manure before it had been spread out in an open yard.

3. The soluble portion of the ash of this manure in April contains, it will be seen, more soluble silica and sulphuric acid than the soluble ash of the manure in November, 1855.

4. The influence of rain on manure spread out in an open yard is best seen by comparing the composition of the whole ash of the manure, analysed in April, with the analysis of the whole ash of the manure in a perfectly fresh state.

In the whole ash of the April manure is less soluble silica, less potash, and much less phosphate of lime, than in the ash of the manure in a fresh state. The most soluble, and at the same time most valuable fertilizing substances thus are washed out by falling rain, and consequently an ash richer in lime and insoluble matters is left on burning the manure on the 30th of April. The actual loss in weight which this experimental heap sustained in the year, is given in the following Table.

Table showing the actual Loss in Weight, and Percentage of Loss in Weight, of Experimental Heap (No. III.), fresh Farmyard Manure, spread, at different periods of the Year.

	Weight of Manure in lbs.	Loss in Original Weight in lbs.	Percentage of Loss.
Put up on the 3rd of November, 1854	1652	..	..
Weighed on the 30th of April, 1855, or after a lapse of 6 months	1429	223	13·4
Weighed on the 23rd of August, 1855, or after a lapse of 9 months and 20 days ..	1012	640	38·7
Weighed on the 15th of November, 1855, or after a lapse of 12 months and 12 days ..	950	702	42·4

The loss in weight on the 30th of April, thus amounted to only 13½ per cent.; but as rain had fallen shortly before the weighing was made in April, the real loss in valuable fertilizing matters is much greater than indicated by the direct weighing. This will appear clearly when the composition of the entire quantity of the manure spread in the open yard shall have been stated. Before doing this, however, I shall endeavour to explain the alterations which the spread manure underwent in the course of the experimental year.

The third series of analyses, incorporated in the subjoined Table, I trust will afford a sure guide in drawing satisfactory conclusions.

Table showing Composition of Experimental Heap (No. III.), fresh Farmyard Manure, spread in open yard, at different periods of the Year. In natural state.

	When put up. Nov. 3rd, 1854.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
Water	66·17	80·02	70·09	65·56
*Soluble organic matters	2·48	1·16	·49	·42
Soluble inorganic matters	1·54	1·01	·64	·57
†Insoluble organic matters	25·76	11·46	10·56	9·94
Insoluble mineral matters	4·05	6·35	18·22	23·51
	100·00	100·00	100·00	100·00
*Containing nitrogen	·149	·08	·06	·03
Equal to ammonia	·181	·09	·07	·036
†Containing nitrogen	·494	·45	·35	·36
Equal to ammonia	·599	·54	·42	·46
Total amount of nitrogen	·643	·53	·41	·39
Equal to ammonia	·780	·63	·49	·496
Ammonia in free state	·034	·010	·012	·0006
Ammonia in form of salts, easily decomposed by quicklime	·088	·045	·051	·030
Total amount of organic matters	28·24	12·62	11·05	10·36
Total amount of mineral substances ..	5·59	7·36	18·86	24·08

It will be observed that this manure contained, on the 30th of April, 14 per cent. more water than when first spread out in the yard. The fact was, that a day before it was analysed and weighed, a good deal of rain had fallen, which of course thoroughly drenched the manure spread about in the yard, whilst it did not thoroughly saturate with moisture the experimental heap No. I. There is thus less moisture in the heap No. I. than in the manure spread out.

By the 23rd of August a great deal of moisture had evaporated, and on the 15th of November very nearly the same proportion of moisture was found which the manure originally contained. We can therefore compare the first with the last analysis without committing any great error, and shall find, on such a comparison, the following interesting particulars:—

1. At the end of the experiment the manure contained, instead of 2½ per cent., not quite ½ per cent. of soluble organic matters.

2. The insoluble organic matters in the course of the year became reduced from 25·7 per cent. to 10 per cent.

3. The soluble nitrogenized constituents appear to have been washed out almost completely, since at the conclusion of the experiment the manure contained only ·03 per cent., or a mere trace of nitrogen.

4. The total percentage of nitrogen in the manure has become considerably diminished in the manure analysed in November, 1855.

The fertilizing value of the manure spread out in an open yard thus became deteriorated by keeping far more considerably than any other of the experimental heaps.

Before offering any further remarks on the experiments with this manure, a Table (p. 247) stating the composition of the manure in a dry state may find here a convenient place.

The analytical data incorporated in this Table are extremely interesting and practically important, inasmuch as they show to what extent farmyard manure may become deteriorated in value by slovenly practice, and how rapidly the most valuable fertilizing constituents are removed by the rain which falls upon the manure.

It will be perceived that the loss in valuable substances is especially great in the warmer months of the year, but I believe it is not so much due to the more elevated temperature that the manure becomes deteriorated, as to the heavy showers of rain which fall in the summer months.

On comparing the amount of the different constituents of the manure in the various experimental periods, it will be observed that all the manuring constituents, with the exception of the insoluble mineral matters, rapidly diminish, so that at last but a

Table showing Composition of Experimental Heap (No. III.), fresh Farmyard Manure, spread, at different periods of the Year. Calculated dry.

	When put up. Nov. 3rd, 1854.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
*Soluble organic matters	7·33	5·80	1·64	1·21
Soluble inorganic matters	4·55	5·05	2·14	1·69
†Insoluble organic matters	76·15	57·37	35·30	28·86
Insoluble mineral matters	11·97	31·78	60·92	68·24
	100·00	100·00	100·00	100·00
*Containing nitrogen	·44	·42	·20	·10
Equal to ammonia	·53	·51	·24	·12
†Containing nitrogen	1·46	2·28	1·17	1·09
Equal to ammonia	1·77	2·76	1·41	1·32
Total amount of nitrogen	1·90	2·70	1·37	1·19
Equal to ammonia	2·30	3·27	1·65	1·44
Ammonia in free state	·10	·05	·040	·0017
Ammonia in form of salts, easily decomposed by quicklime	·26	·225	·171	·087
Total amount of organic matters	83·48	63·17	36·94	30·07
Total amount of mineral substances ..	16·52	36·83	63·06	69·93

small proportion of the original fertilizing matters is left behind.

Thus the soluble organic matters sink from 7·33 per cent. to 5·8 per cent. in the course of six months, to 1·64 per cent. in nine months, and to 1·21 per cent. in twelve months. With this loss in soluble organic matters the percentage of nitrogen, present in the form of soluble compounds, gradually sinks from ·44 per cent. to ·10 per cent. That this loss in nitrogen is not entirely due to the evaporation of ammonia, is shown by the simultaneous diminution of the amount of soluble inorganic matters, which became reduced from 4·55 per cent. to 1·69.

Still more conspicuous is the loss in insoluble organic matters. Thus we have in the fresh dry manure 76·15 per cent. of insoluble organic matters. After a lapse of six months only 57·37 per cent. are left behind; after nine months but 35·3 per cent., and after twelve months merely 28·86 per cent.

Similar striking differences in the composition of the manure at the stated periods will manifest themselves on an attentive perusal of the foregoing tabulated analytical results. They all tend to prove the enormous waste which is incurred by keeping for a lengthy period farmyard manure exposed in thin layers to the influence of the weather. But I must hasten to ascertain the precise loss in the various constituents which this manure sustained in the course of a year.

This loss will become apparent by an inspection of the fol-

lowing Table, in which is stated the composition of the entire mass of the experimental manure No. III.

Table showing Composition of entire mass of Experimental Manure (No. III.), fresh Farmyard Manure, spread. In Natural State. Expressed in lbs. and fractions of lbs.

	When put up. Nov. 3rd, 1854.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
Weight of manure	1652·	1429·	1012·	950·
Amount of water in the manure	1093·	1143·	709·3	622·8
Amount of dry matter	559·	285·5	302·7	327·2
Consisting of—				
*Soluble organic matter	40·97	16·55	4·96	3·95
Soluble mineral matter	25·43	14·41	6·47	5·52
†Insoluble organic matter	425·67	163·79	106·81	94·45
Insoluble mineral matter	66·93	90·75	184·46	223·28
	559·00	285·50	302·70	327·20
*Containing nitrogen	3·28	1·19	·60	·32
Equal to ammonia	3·98	1·44	·73	·39
†Containing nitrogen	6·21	6·51	3·54	3·56
Equal to ammonia	7·54	7·90	4·29	4·25
Total amount of nitrogen in manure ..	9·49	7·70	4·14	3·88
Equal to ammonia	11·52	9·34	5·02	4·64
The manure contains ammonia in free state	·55	·14	·13	·0055
,, ,, ammonia in form of salts, easily decomposed by quicklime	1·45	·62	·55	·28
Total amount of organic matters	466·64	180·34	111·77	98·40
Total amount of mineral matters	92·36	105·16	190·93	228·80

This Table requires an explanatory notice. It will be observed that the amount of insoluble mineral matters in the manure increases greatly in every succeeding experimental period. Especially it is great in November, 1855. This increase is due entirely to accidental admixtures of earthy matters, which could not be excluded without losing some of the manure. It was found, namely, impossible to collect the manure properly without mixing with it some of the soil over which it was spread. On the 23rd of August, 1855, the manure had shrunk to a very small bulk, and on the 15th of November, 1855, the greater portion of the manure appeared to have gone either into the air or to have been washed into the soil. It was necessary therefore to scrape the soil as close as possible in order not to lose any of the manure, and it is due to this circumstance that at the conclusion of the experiment a very much larger proportion of insoluble mineral substances was found than in the perfectly fresh manure. I may mention, however, that the whole mass of the spread manure has

been most carefully mixed before a sample was taken for analysis. The earthy matters I have every reason to believe were intimately mixed with the manure; and since the composition of the entire mass has been calculated from the data already furnished, the general deductions which may be derived from my experiments are not affected by this circumstance. In speaking of the loss which this manure sustained in keeping, I will select the more important fertilizing constituents for illustration, and in reference to them beg to make the following observations:—

1. The weight of the whole manure, when spread out in an enclosed yard, amounted to 1652 lbs. In this quantity were present 40·97, or nearly 41 lbs. of soluble organic matters. After the lapse of six months only 16½ lbs. were left in the manure; in nine months barely 5 lbs., and after twelve months merely 4 lbs.

Thus only about 1-10th part of the original quantity of soluble organic matters was left over by keeping fresh farmyard manure spread out in an open yard.

2. The nitrogen contained in the 41 lbs. of soluble organic matters amounted to 3·28 lbs. After six months only 1·19 lbs. of nitrogen, in the state of soluble compounds, was left; after nine months little more than ½ lb., and after twelve months only ⅓ of a lb. In other words, the nitrogen in the state of soluble compounds has disappeared almost entirely in the course of a year.

3. In an equally considerable degree the soluble mineral matters were dissipated in the manure. Originally the manure contained 25·43 lbs. of soluble mineral matters. After six months this quantity became reduced to 14·41 lbs.; after nine months to to 6·47 lbs., and after a lapse of twelve months to 5·52 lbs.

On the whole the manure thus lost 78·2 per cent. of the original quantity of soluble mineral matters.

4. Still more striking is the loss in insoluble organic matters. In the fresh manure were present 425·67 lbs. of insoluble organic substances. In the course of six months these became reduced to 163·79 lbs.; a further exposure of rather more than three months to the weather reduced this quantity to 106·81 lbs., and after twelve months merely 94·45 lbs. were left over. The manure lost thus no less than 77·7 per cent. of the original quantity of insoluble organic matters.

5. If we look to the total amount of nitrogen, we shall find that the original proportion of nitrogen in the manure, amounting to 9·49 lbs., was reduced in the course of six months to 7·70 lbs., after nine months to 4·14 lbs., and after twelve months to 3·88 lbs.

At the conclusion of the experiment more than half the quantity, or, in exact numbers, 59·1 per cent. of the nitrogen contained in the fresh manure, was wasted.

6. If we replace, in the analysis made on the 15th November, 1855, the number which expresses the amount of insoluble mineral matters by the number 66·93, expressing the proportion of insoluble mineral matters which the manure contained at the commencement of the experiment, and which it would have also contained had no earthy matters been mixed up with the manure, and add to it the other constituents, we obtain for the corrected composition of the whole manure in November, 1855, the following numbers, which for comparison's sake are contrasted with the analysis of the fresh manure of November, 1854:—

	When put up, Nov. 3, 1854. lbs.	At conclusion of experiment, Nov. 15, 1855. lbs.
Weight of the manure	1652	950
Amount of water in the manure	1093	622·8
„ dry substances	559	170·85
Consisting of:—		
Soluble organic matters	40·97	3·95
*Soluble mineral matters	25·43	5·52
†Insoluble organic matters	425·67	94·45
Insoluble mineral matters	66·93	66·93
	559·00	170·85
* Containing nitrogen	3·28	·32
Equal to ammonia	3·98	·39
† Containing nitrogen	6·21	3·56
Equal to ammonia	7·54	4·25
Total amount of nitrogen in manure	9·49	3·88
Equal to ammonia	11·52	4·64
The whole manure contained:—		
Ammonia in free state	·55	·0055
Ammonia in form of salts readily decomposed by quicklime	1·45	·28
Total amount of organic matters	466·64	98·40
„ mineral matters	92·36	72·45

It will hence appear from these results that the experiment was begun with 559 lbs. of dry manure; after the lapse of twelve months, only 170·85 lbs. were left behind. Kept for this length of time spread in an open yard, the manure thus lost no less than 69·8 per cent. in fertilizing matters; or, in round numbers, *two-thirds of the manure were wasted, and only one-third was left behind.* This fact teaches a most important lesson, and speaks for itself so forcibly that any further comment appears to me useless. In conclusion of this third series of experiments, I may, however, give a Table which may be found useful in calculating the loss in the various fertilizing matters in any given quantity of farmyard manure kept in a similar manner, in which the experimental manure No. III. was kept.

Table showing Loss in the different component parts of Experimental Heap, No. III., Fresh Farmyard Manure (No. III.), Spread, at different periods of the Year; also Percentage of Loss and Loss per Ton of Fresh Manure.—Quantities stated in lbs. and Fractions of lbs. (N.B. The sign * prefixed to a number indicates Increase instead of Loss.)

	From November 3, 1854,								
	To April 30, 1855. Kept 6 Months.			To August 23, 1855. Kept 9 Months.			To November 15, 1855. Kept 12 Months.		
Loss in weight of—		Per cent.	Per ton.		Per cent.	Per ton.		Per cent.	Per ton.
Entire heap	223·	13·49	296·77	640·	38·74	867·77	702·	42·49	951·77
Water	*50·	*3·02	*67·64	383·7	23·22	520·12	470·20	28·46	637·50
*Soluble organic matter	24·42	1·47	32·92	36·01	2·18	48·83	37·02	2·24	50·17
Soluble mineral matter	11·02	·66	14·78	18·96	1·14	25·53	19·91	1·20	26·88
†Insoluble organic matter	261·88	15·85	355·04	318·86	19·29	432·09	331·22	20·05	449·12
Insoluble mineral matter	*23·82	*1·44	*32·25	*117·54	*7·11	*159·26	*156·86	*9·40	*210·56
*Containing nitrogen	2·09	·12	2·63	2·68	·16	3·58	2·96	·18	4·03
Equal to ammonia	2·54	·15	3·36	3·25	·19	4·25	3·59	·21	4·70
†Containing nitrogen	*·30	*·018	*·40	2·67	·16	3·88	2·66	·16	3·58
Equal to ammonia	*·36	*·021	*·50	3·25	·19	4·25	3·29	·19	4·25
Total amount of nitrogen	1·79	·102	2·28	5·35	·32	7·16	5·61	·34	7·61
Equal to ammonia	2·18	·129	2·93	6·50	·38	8·51	6·88	·41	9·18
Ammonia in free state	·41	·024	·53	·42	·025	·56	·5445	·033	·73
Ditto in form of salts	·83	·050	1·12	·90	·050	1·12	1·17	·07	1·56
Total amount of organic matter	286·30	17·32	387·96	354·87	21·47	480·92	368·24	22·29	499·29
Ditto mineral matter	*12·80	*·78	*17·47	*98·57	*5·97	*133·73	*136·44	*8·25	*184·90

Experimental Heap (No. IV.), *Well-rotten Dung, Exposed.*—Mixed horse, cow, and pig manure.

The fourth and last series of experiments was begun on the 5th of December, 1854, with a view of ascertaining whether or not well-rotten manure is deteriorated in value more rapidly than fresh dung, produced by the same description of animals. The weighings were made on the same days on which the weight of the three preceding experimental heaps were ascertained. In the following Table the results of the direct weighings are stated:

Table showing the Weights of Experimental Heap (No. IV.), Well-rotten Dung, Exposed, and Percentage of Loss.

	Weight of Manure in lbs.	Loss in Original Weight in lbs.	Percentage of Loss.
Put up on the 5th of December, 1854	1613	..	..
Weighed on the 30th of April, 1855, or after a lapse of 4 months and 25 days	1186	427	26·5
Weighed on the 23rd of August, 1855, or after a lapse of 8 months and 18 days ..	1023	590	36·5
Weighed on the 15th of November, 1855, or after a lapse of 11 months and 10 days ..	1003	610	37·8

Analysed at the same periods at which the weighings were made, the following results were obtained:—

Table showing Composition of Experimental Manure (No. IV.), Well-rotten Dung, Exposed. In natural state.

	When put up. Dec. 5th, 1854.	Feb. 14th, 1855.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
Water	75·42	73·90	68·93	72·25	71·55
*Soluble organic matters	3·71	2·70	2·21	1·50	1·13
Soluble inorganic matters ..	1·47	2·06	1·68	1·10	1·04
†Insoluble organic matters ..	12·82	14·39	15·87	12·46	12·35
Insoluble mineral matters ..	6·58	6·95	11·31	12·69	13·93
	100·00	100·00	100·00	100·00	100·00
*Containing nitrogen	·297	·149	·14	·090	·09
Equal to ammonia	·360	·180	·17	·109	·11
†Containing nitrogen	·309	·610	·76	·490	·56
Equal to ammonia	·375	·740	·92	·600	·69
Total amount of nitrogen ..	·606	·759	·90	·580	·65
Equal to ammonia	·735	·920	1·09	·709	·80
Ammonia in free state	·046	·015	·006	·013	·003
Ammonia in form of salts, easily decomposed by quicklime ..	·057	·048	·044	·040	·029
Total amount of organic matters	16·53	17·09	18·08	13·96	13·48
Total amount of mineral substances	8·05	9·01	12·99	13·79	14·97

It will be seen that at the conclusion of the experiment the manure contained about 4 per cent. less moisture than it did at the beginning. In each experimental period the percentage of water was different, and consequently the direct weighings do not represent accurately the percentage of real loss. In the next Table is given the composition of the same manure, calculated dry.

Table showing Composition of Experimental Manure (No. IV.), Well-rotten Dung, Exposed, at different periods of the Year. In dry state.

	When put up. Dec. 5th, 1854.	Feb. 14th, 1855.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
*Soluble organic matters	15·09	10·34	7·11	5·41	3·99
Soluble inorganic matters ..	5·98	7·89	5·41	3·96	3·67
†Insoluble organic matters ..	52·15	55·13	51·08	44·90	43·39
Insoluble mineral matters ..	26·78	26·64	36·40	45·73	48·95
	100·00	100·00	100·00	100·00	100·00
*Containing nitrogen	1·21	·57	·45	·32	·32
Equal to ammonia	1·47	·69	·54	·39	·39
†Containing nitrogen	1·26	2·35	2·44	1·76	1·98
Equal to ammonia	1·53	2·85	2·96	2·16	2·40
Total amount of nitrogen ..	2·47	2·92	2·89	2·08	2·30
Equal to ammonia	3·00	3·54	3·50	2·55	2·79
Ammonia in free state	·189	·057	·018	·047	·012
Ammonia in form of salts, easily decomposed by quicklime ..	·232	·183	·137	·144	·104
Total amount of organic matters	67·24	65·47	58·19	50·31	47·38
Total amount of mineral substances	32·76	34·53	41·81	49·69	52·62

It will appear from these analyses that in well-rotten farmyard manure the soluble constituents are more readily wasted than is the case with fresh dung kept in the same manner. On the other hand, the percentage of insoluble organic matters, practically speaking, sustained no diminution by keeping the manure in a heap exposed to the weather from December 5th, 1854, to April 30th, 1855. In the two succeeding periods, embracing the warmer months of the year, an appreciable loss in the insoluble organic matters appears to have taken place; and it is in the two last periods that the soluble constituents have been wasted more abundantly than in the preceding months.

The nature of this loss will become more conspicuous if we calculate from the foregoing data the composition of the whole experimental heap No. IV. This has been done in the subjoined Table:—

Table showing Composition of Whole Heap (No. IV.), Well-rotten Dung, Exposed. In Natural State. Expressed in lbs. and fractions of lbs.

	When put up. Dec. 5th, 1854.	April 30th, 1855.	Aug. 23rd, 1855.	Nov. 15th, 1855.
Weight of manure	1613·	1186·	1023·	1003·
Amount of water in the manure	1216·5	818·	739·1	737·7
Amount of dry matter	396·5	368·	283·9	285·3
Consisting of—				
*Soluble organic matter	59·83	26·16	15·35	11·38
Soluble mineral matter	23·71	19·90	11·24	10·47
†Insoluble organic matters	206·77	187·97	127·47	123·79
Insoluble mineral matters	106·19	133·97	129·84	139·66
	396·5	368·	283·9	285·30
*Containing nitrogen	4·79	1·73	·90	·92
Equal to ammonia	5·81	2·10	1·09	1·11
†Containing nitrogen	4·99	8·99	4·99	5·65
Equal to ammonia	6·08	10·91	6·06	6·89
Total amount of nitrogen in manure ..	9·78	10·72	5·89	6·57
Equal to ammonia	11·89	13·01	7·15	8·00
The manure contains ammonia in free state	·74	·066	·13	·034
,, ,, ammonia in form of salts, easily decomposed by quicklime	·92	·50	·40	·29
Total amount of organic matters	266·60	214·13	142·82	135·17
Total amount of mineral matters	129·90	153·87	141·08	150·13

A careful comparison of these analytical results will show:—

1. That well-rotten dung loses little in substance during the colder months of the year, provided no heavy rain falls. Should there be continued rainy weather, the result, I have no doubt, would be different from that obtained in my experiments.

2. In the warmer months of the year rotten dung decreases in bulk and in weight more rapidly than in the colder seasons of the year.

3. The loss which well-rotten dung sustains affects principally the soluble constituents.

4. Although rotten dung diminishes less in weight than fresh dung kept in the same manner for the same length of time, yet rotten dung is more readily deteriorated in intrinsic value than fresh. This arises from the circumstance that in rotten dung the proportion of soluble matters is much larger than in fresh. Thus it will be seen that from 59·83 lbs. of soluble organic substances originally present in the manure, only 11·38 lbs. were left over at the conclusion of the experiment, and from 23·71 soluble mineral matters only 10·47 lbs.

5. It will be seen also that hardly a trace of the free ammonia present in the manure when first used for this series of experiments is left over by November, 1855; and that also the ammonia present in the form of salts, which are easily decomposed by quicklime, is almost altogether dissipated.

6. Finally, it may be observed that in rotten dung exposed to the weather (rain), the nitrogen present in the form of soluble compounds (principally ammoniacal salts) is much more rapidly wasted than in fresh dung.

The whole tenor of this fourth series of experiments agrees well with the first series. Having given in the previous pages a detailed account of the changes which fresh manure undergoes in becoming rotten, I shall not offer any further remarks, and conclude this experimental series by the subjoined tabulated statements which may be found acceptable:—

Table showing Loss in the different component parts of Experimental Heap, No. IV., well-rotten Dung, Exposed, at different periods of the Year, in natural state; also Percentage of Loss and Loss per Ton of original Rotten Dung.—Expressed in lbs. and fractions of lbs. (N.B. The sign * prefixed to a number expresses Increase, and not Loss.)

	From December 5, 1854.								
	To April 30, 1855. Kept 5 Months.			To August 23, 1855. Kept 8 Months.			To November 15, 1855. Kept 11 Months.		
Loss in weight of—		Per cent.	Per ton.		Per cent.	Per ton.		Per cent.	Per ton
Entire heap	427·	26·47	615·32	590·	36·57	819·16	610·	37·82	847·16
Water	398·5	24·70	533·28	477·4	29·47	660·12	478·8	29·69	665·05
*Soluble organic matter	33·67	2·06	46·14	44·48	2·81	62·94	48·45	3·00	67·20
Soluble mineral matter	4·81	·29	6·49	12·47	·77	17·24	13·24	·82	18·36
†Insoluble organic matter	18·80	1·16	25·93	79·30	4·92	110·20	82·98	5·14	115·13
Insoluble mineral matter	*27·78	*1·72	*38·52	*23·65	*1·46	*32·70	*33·47	*2·07	*46·36
*Containing nitrogen	3.06	·18	4·03	3·89	·24	5·37	3·87	·24	5 37
Equal to ammonia	3·71	·23	5·15	4·72	·29	6·49	4·70	·29	6·49
†Containing nitrogen	*4·00	*·24	*5·37	0·	0·	0·	*·66	*·04	*·89
Equal to ammonia	4·83	·29	6·49	·02	·001	·02	*·81	*·05	1·12
Total amount of nitrogen	*·94	*·05	*1·12	3·89	·24	5·37	3·21	·19	4·48
Equal to ammonia	*1·12	*·07	*1.56	4·72	·29	6·49	3·89	·24	5·37
Ammonia in free state	·674	·04	·89	·61	·03	·67	·706	·04	·89
Ammonia in form of salts	·42	·02	·44	·52	·03	·67	·63	·04	·89
Total amount of organic matters	52·47	3·22	72·12	123·78	7·73	173·14	131·43	8·14	182·33
Total amount of mineral matters	*22·97	1·43	*32·03	*11·18	*·69	*15·45	*20·23	*1·25	*28·00

In conclusion, I may mention that I have tested the various experimental manures at different times for nitrates, and have been able to detect the presence of nitric acid in most cases in which the manure had been kept for some time in contact with the atmosphere. Under all circumstances, however, the proportion of nitric acid appeared to amount to mere traces; and, as I am not acquainted with any accurate method of determining minute quantities of nitric acid in so complex a mixture of substances as that of farmyard manure, I have not attempted to determine the amount of nitric acid in the manure quantitively. I may be permitted, however, briefly to state the results of my qualitative examinations:—

Qualitative examination for Nitrates.

Fresh farmyard manure (about 14 days old) examined Nov. 3rd, 1854 ..	No reaction.
Well-rotten dung taken from the bottom of manure-pit on the 5th of Dec., 1854	,,

Analyses made February 14th, 1855.

Experimental heap, No. I., fresh farmyard manure exposed	Decided traces of nitric acid.
Experimental heap, No. II., fresh farmyard manure under shed	Doubtful trace of nitric acid.
Experimental heap, No. III., well-rotten dung exposed	Nitric acid distinctly present, apparently in larger proportion than in No. I.

Analyses made April 30th, 1855.

Experimental heap, No. I., fresh manure exposed	Distinct traces of nitric acid.
Experimental heap, No. II., fresh manure under shed	,, ,,
Experimental heap, No. III., fresh manure spread out	No reaction.
Experimental heap, No. IV., well-rotten dung exposed	Distinct traces of nitric acid.

Analyses made August 23rd, 1855.

Experimental heap, No. I., fresh manure exposed	Distinct traces of nitric acid.
Experimental heap, No. II., fresh manure under shed	The same as in May.
Experimental heap, No. III., fresh manure spread out	A faint trace.
Experimental heap, No. IV., well-rotten dung exposed	Stronger reaction of nitric acid, than in May.

It will be seen that there was no nitric acid present in the fresh manure, nor in the rotten dung taken from the bottom of the pit; and, as traces of nitrates were detected in the manure after a three-months' exposure to the weather, it would seem to follow that access of air is essential for the formation of nitrates

in the manure. I was rather surprised not to find any decided traces of nitric acid in the manure spread out in the yard. But as nitrates are very soluble in water, and the spread manure contained a very small proportion of soluble saline matters, it is evident that, if nitrates have been formed, they must have been washed into the soil on which the manure was spread.

Conclusion.—Having described at length my experiments with farmyard manure, it may not be amiss to state briefly the more prominent and practically interesting points which have been developed in the course of this investigation. I would therefore observe,—

1. Perfectly fresh farmyard manure contains but a small proportion of free ammonia.

2. The nitrogen in fresh dung exists principally in the state of insoluble nitrogenized matters.

3. The soluble organic and mineral constituents of dung are much more valuable fertilizers than the insoluble. Particular care, therefore, should be bestowed upon the preservation of the liquid excrements of animals, and for the same reason the manure should be kept in perfectly waterproof pits, of sufficient capacity to render the setting up of dungheaps in the corner of fields, as much as it is possible, unnecessary.

4. Farmyard manure, even in quite a fresh state, contains phosphate of lime, which is much more soluble than has hitherto been suspected.

5. The urine of the horse, cow, and pig, does not contain any appreciable quantity of phosphate of lime, whilst the drainings of dungheaps contain considerable quantities of this valuable fertilizer. The drainings of dungheaps, partly for this reason, are more valuable than the urine of our domestic animals, and therefore ought to be prevented by all available means from running to waste.

6. The most effectual means of preventing loss in fertilizing matters is to cart the manure directly on the field whenever circumstances allow this to be done.

7. On all soils with a moderate proportion of clay no fear need to be entertained of valuable fertilizing substances becoming wasted if the manure cannot be ploughed in at once. Fresh, and even well-rotten, dung contains very little free ammonia; and since active fermentation, and with it the further evolution of free ammonia, is stopped by spreading out the manure on the field, valuable volatile manuring matters cannot escape into the air by adopting this plan.

As all soils with a moderate proportion of clay possess in a remarkable degree the power of absorbing and retaining manuring

matters, none of the saline and soluble organic constituents are wasted even by a heavy fall of rain. It may, indeed, be questioned whether it is more advisable to plough-in the manure at once, or to let it lie for some time on the surface, and to give the rain full opportunity to wash it into the soil.

It appears to me a matter of the greatest importance to regulate the application of manure to our fields so that its constituents may become properly diluted and uniformly distributed amongst a large mass of soil. By ploughing in the manure at once, it appears to me, this desirable end cannot be reached so perfectly as by allowing the rain to wash in gradually the manure evenly spread on the surface of the field.

By adopting such a course, in case practical experience should confirm my theoretical reasoning, the objection could no longer be maintained that the land is not ready for carting manure upon it. I am much inclined to recommend as a general rule: Cart the manure on the field, spread it at once, and wait for a favourable opportunity to plough it in. In the case of clay soils, I have no hesitation to say the manure may be spread even six months before it is ploughed in, without losing any appreciable quantity of manuring matters. I am perfectly aware that, on stiff clay-land, farmyard manure, more especially long dung, when ploughed in before the frost sets in, exercises a most beneficial action by keeping the soil loose and admitting the free access of frost, which pulverizes the land,—and would therefore by no means recommend to leave the manure spread on the surface without ploughing it in. All I wish to enforce is, that when no other choice is left but either to set up the manure in a heap in a corner of the field, or to spread it on the field, without ploughing it in directly, to adopt the latter plan. In the case of very light sandy soils it may perhaps not be advisable to spread out the manure a long time before it is ploughed in, since such soils do not possess the power of retaining manuring matters in any marked degree. On light sandy soils I would suggest to manure with well-fermented dung shortly before the crop intended to be grown is sown.

8. Well-rotten dung contains likewise little free ammonia, but a very much larger proportion of soluble organic and saline mineral matters than fresh manure.

9. Rotten dung is richer in nitrogen than fresh.

10. Weight for weight, rotten dung is more valuable than fresh.

11. In the fermentation of dung a very considerable proportion of the organic matters in fresh manure, is dissipated into the air in the form of carbonic acid and other gases.

12. Properly regulated, however, the fermentation of dung is

not attended with any great loss of nitrogen nor of saline mineral matters.

13. During the fermentation of dung, ulmic, humic, and other organic acids are formed, as well as gypsum, which fix the ammonia generated in the decomposition of the nitrogenized constituents of dung.

14. During the fermentation of dung the phosphate of lime which it contains is rendered more soluble than in fresh manure.

15. In the interior and heated portions of manure-heaps ammonia is given off; but, on passing into the external and cold layers of dungheaps, the free ammonia is retained in the heap.

16. Ammonia is not given off from the surface of well-compressed dungheaps, but on turning manure-heaps it is wasted in appreciable quantities. Dungheaps for this reason should not be turned more frequently than absolutely necessary.

17. No advantage appears to result from carrying on the fermentation of dung too far, but every disadvantage.

18. Farmyard manure becomes deteriorated in value, when kept in heaps exposed to the weather; the more the longer it is kept.

19. The loss in manuring matters, which is incurred in keeping manure-heaps exposed to the weather, is not so much due to the volatilization of ammonia as to the removal of ammoniacal salts, soluble nitrogenized organic matters, and valuable mineral matters, by the rain which falls in the period during which the manure is kept.

20. If rain is excluded from dung-heaps, or little rain falls at a time, the loss in ammonia is trifling, and no saline matters of course are removed; but, if much rain falls, especially if it descends in heavy showers upon the dungheap, a serious loss in ammonia, soluble organic matters, phosphate of lime, and salts of potash is incurred, and the manure becomes rapidly deteriorated in value, whilst at the same time it is diminished in weight.

21. Well-rotten dung is more readily affected by the deteriorating influence of rain than fresh manure.

22. Practically speaking, all the essentially valuable manuring constituents are preserved by keeping farmyard manure under cover.

23. If the animals have been supplied with plenty of litter, fresh dung contains an insufficient quantity of water to induce an active fermentation. In this case fresh dung cannot be properly fermented under cover, except water or liquid manure is pumped over the heap from time to time.

Where much straw is used in the manufacture of dung, and no provision is made to supply the manure in the pit at any time with the requisite amount of moisture, it may not be ad-

visable to put up a roof over the dung-pit. On the other hand, on farms where there is deficiency of straw, so that the moisture of the excrements of our domestic animals is barely absorbed by the litter, the advantage of erecting a roof over the dung-pit will be found very great.

24. The worst method of making manure is to produce it by animals kept in open yards, since a large proportion of valuable fertilizing matters is wasted in a short time; and after a lapse of twelve months at least two-thirds of the substance of the manure is wasted, and only one-third, inferior in quality to an equal weight of fresh dung, is left behind.

25. The most rational plan of keeping manure in heaps appears to me that adopted by Mr. Lawrence of Cirencester, and described by him at length in Morton's 'Cyclopædia of Agriculture,' under the head of 'Manure.'

APPENDIX.

The methods employed for determining the water, and selecting samples for analysis, have been stated already in the preceding pages. I can, therefore, proceed at once with the description of the other methods which were adopted in the analysis of the manure.

One thousand, and sometimes two thousand, grains of a carefully mixed sample of manure were digested in a glass beaker with about 16 ounces of cold distilled water for about three or four hours. The liquid was then strained through calico, and the residue digested a second time with about 10 ounces of water; the liquid was again passed through calico, and the residue thoroughly squeezed out. It was next digested again in water, pressed out, and repeatedly washed on the calico until the water came perfectly clear through the calico, and left on evaporation merely a trace of solid matter. In this way a quantity of liquid was obtained (by employing 1000 grains of manure), which filled about a Winchester quart. As it was impossible to obtain a perfectly clear liquid by repeated filtrations through fine filtering paper, the watery solution of the dung was kept in carefully-stoppered Winchester quarts for three or four days, or until the liquid became perfectly clear on standing. It was then drawn off with a syphon into another bottle, and the deposit in the first bottle carefully collected in a weighed filter, and this weight added afterwards to that of the portion of dung insoluble in water. The insoluble portion was previously dried in the air-bath at 212° Fah.

The weight of the whole solution having been ascertained, separate portions of it were employed for the determination of the total amount of soluble matters. Generally three, sometimes four, weighed portions of the liquid were evaporated separately to dryness, first in glass beakers, and finally in a large platinum basin over the water-bath. The platina basin and residue was then dried in the air-bath, until it ceased to lose in weight.

The dry residue of two evaporations was burned over the gas-lamp to a whitish ash, and thus the amount of soluble organic and inorganic matters determined. The dry residue of the third and fourth evaporation was reserved for the determination of the nitrogen in the soluble matters of the manure.

In a similar manner the proportions of organic and inorganic matters in the insoluble portion of the manure was ascertained.

The nitrogen was determined in each portion separately by combustion with soda-lime, and collecting the ammonia produced in sulphuric acid of known strength, according to Peligot's method of determining nitrogen in organic matters.

Frequently two combustions were made with one and the same substance, and invariably closely-agreeing results obtained.

The ash-analyses of the soluble and the insoluble mineral matters of manure, were executed according to the method described in Professor Wöhler's 'Handbook of Inorganic Analysis,' under the head "Analyses of the Ashes of Plants."

The amount of free ammonia in the manure was ascertained by placing into a wide-mouthed retort from 500 to 1000 grains of manure, adding about 8 ounces of water, and distilling off about 4 ounces into a glass bottle, connected air-tight with the retort on the one hand, and on the other with the bulb apparatus usually employed in nitrogen combustions. Both the bottle and the bulb apparatus contained some hydro-chloric acid. The contents of both were evaporated to dryness on the water-bath, and from the dried residue the amount of free ammonia calculated.

To the manure in the retort, from which the free ammonia was distilled off, quicklime and a little more water was added, and the whole distilled nearly to dryness into hydro-chloric acid as before.

Distilled water was next poured upon the mixture of quicklime and manure in the retort, and after some time the liquid filtered through filtering paper. The insoluble portion was washed several times, and the washings added to the first filtrate, and the whole clear solution evaporated to a very small bulk.

This condensed liquid, which in most cases was coloured merely light yellow, finally was tested for nitric acid with the usual tests.

IX.—*Management of Dairy Cattle.* 1854 to 1856. By T. Horsfall.

On entering upon a description of my treatment of cows for dairy purposes, it seems pertinent that I should give some explanation of the motives and considerations which influence my conduct in this branch of my farm operations.

I have found it stated, on authority deserving attention, that store cattle of a fair size, and without other occupation, maintain their weight and condition for a length of time, when supplied daily with 120 lbs. of Swedish turnips and a small portion of straw. The experience of the district of Craven, in Yorkshire, where meadow hay is the staple food during winter, shows that such cattle maintain their condition on 1½ stone of meadow hay each per day. These respective quantities of turnips and of hay correspond very closely in their nutritive properties; they contain a very similar amount of albuminous matter, starch, sugar, &c., and also of phosphoric acid. Of oil—an important element, especially for the purpose of which I am treating—the stated supply of meadow hay con-

tains more than that of turnips. If we supply cows in milk of average size with the kind and quantity of food above mentioned, they will lose perceptibly in condition. This is easily explained when we find their milk rich in substances which serve for their support when in store condition, and which are shown to be diverted in the secretion of milk.

In the neighbourhood of towns where the dairy produce is disposed of in new milk, and where the aim of dairymen is to produce the greatest quantity, too frequently with but little regard to quality, it is their common practice to purchase in-calving cows; they pay great attention to the condition of the cow; they will tell you, by the high comparative price they pay for animals well stored with flesh and fat, that condition is as valuable for them as it is for the butcher; they look upon these stores as materials which serve their purpose; they supply food more adapted to induce quantity than quality, and pay but little regard to the maintenance of the condition of the animal. With such treatment, the cow loses in condition during the process of milking, and when no longer profitable, is sold to purchasers in farming districts where food is cheaper, to be fattened or otherwise replenished for the use of the dairy keeper. We thus find a disposition in the cow to apply the aliment of her food to her milk, rather than to lay on flesh or fat; for not only are the elements of her food diverted to this purpose, but to all appearance her accumulated stores of flesh and fat are drawn upon, and converted into components of milk, cheese, or butter.

As I am differently circumstanced, a considerable portion of my dairy produce being intended for butter, for which poor milk is not adapted, and as I fatten not only my own cows, but purchase others to fatten in addition, I have endeavoured to devise food for my milch cows, adapted to their maintenance and improvement, and with this view I have paid attention to the composition of milk. From several analyses I have selected one by Haidlen, which I find in publications of repute. Taking a full yield of milk, 4 gallons per day, which will weigh upwards of 40 lbs., this analysis assigns to it of dry material 5·20, of which the proportion, with sufficient accuracy for my purpose, consists of—

	lbs.
Pure caŝein	2·00
Butter	1·25
Sugar	1·75
Phosphate of lime }	·09
Chloride of potassium }	
And other mineral ingredients }	·11
	5·20

It appeared an object of importance, and one which called for my particular attention, to afford an ample supply of the elements of food suited to the maintenance and likewise to the produce of the animal, and that, if I omitted to effect this, the result would be imperfect and unsatisfactory. By the use of ordinary farm produce only, I could not hope to accomplish my purpose. Turnips are objectionable on account of their flavour; and I seek to avoid them as food for dairy purposes. I use cabbages, kohl rabi, and mangold wurzel, yet only in moderate quantities. Of meadow hay it would require, beyond the amount necessary for the maintenance of the cow, an addition of fully 20 lbs. for the supply of casein in a full yield of milk (16 quarts); 40 lbs. for the supply of oil for the butter; whilst 9 lbs. seem adequate for that of the phosphoric acid. You cannot, then, induce a cow to consume the quantity of hay requisite for her maintenance, and for a full yield of milk of the quality instanced. Though it is a subject of controversy whether butter is wholly derived from vegetable oil, yet the peculiar adaptation of this oil to the purpose will, I think, be admitted. I had, therefore, to seek assistance from what are usually termed artificial feeding substances, and to select such as are rich in albumen, oil, and phosphoric acid; and I was bound also to pay regard to their comparative cost, with a view to profit, which, when farming is followed as a business, is a necessary, and in any circumstances an agreeable accompaniment.

I think it will be found that substances peculiarly rich in nitrogenous or other elements have a higher value for special than for general purposes; and that the employment of materials characterized by peculiar properties for the attainment of special objects has not yet gained the attention to which it is entitled.

I have omitted all reference to the heat-supplying elements—starch, sugar, &c. As the materials commonly used as food for cattle contain sufficient of these to effect this object, under exposure to some degree of cold, I have a right to calculate on a less consumption of them as fuel, and consequently a greater surplus for deposit as sugar, and probably also as fat, in consequence of my stalls being kept during winter at a temperature of nearly 60 degrees.

I now proceed to describe the means I am using to carry out the purposes which I have sought to explain. My food for milch cows, after having undergone various modifications, has for two seasons consisted of rape-cake 5 lbs., and bran 2 lbs. for each cow, mixed with a sufficient quantity of bean-straw, oat-straw, and shells of oats, in equal proportions, to supply them three times a day with as much as they will eat. The whole of the materials are moistened and blended together, and after

being well steamed, are given to the animals in a warm state. The attendant is allowed 1 lb. to 1½ lb. per cow, according to circumstances, of bean-meal, which he is charged to give to each cow in proportion to the yield of milk, those in full milk getting 2 lbs. each per day, others but little: it is dry and mixed with the steamed food on its being dealt out separately; when this is eaten up, green food is given, consisting of cabbages, from October to December, kohl rabi till February, and mangold till grass time. With a view to nicety of flavour, I limit the supply of green food to 30 to 35 lbs. per day for each. After each feed 4 lbs. of meadow hay, or 12 lbs. per day, is given to each cow; they are allowed water twice per day to the extent they will drink.

As several of these materials are not commonly used as food, I may be allowed some observations on their properties. Bean-straw uncooked is dry and unpalatable; by the process of steaming, it becomes soft and pulpy, emits an agreeable odour, and imparts flavour and relish to the mess. For my information and guidance I obtained an analysis of bean-straw of my own growth, on strong and high-conditioned land: it was cut on the short side of ripeness, but yielding a plump bean. The analysis by Professor Way shows a per-centage of—

Moisture	14·47
Albuminous matter	16·38
Oil or fatty matter	2·23
Woody fibre	25·84
Starch, gum, &c.	31·63
Mineral matters	9·45
Total	100·00

In albuminous matter, which is especially valuable for milch cows, it has nearly double the proportion contained in meadow hay. Bran also undergoes a great improvement in its flavour by steaming, and it is probably improved in its convertibility as food; it contains about 14 per cent. of albumen, and is peculiarly rich in phosphoric acid, nearly 3 per cent. of its whole substance being of this material. The properties of rape-cake are well known; the published analyses give it a large proportion (nearly 30 per cent.) of albumen; it is rich in phosphates and also in oil. This is of the unctuous class of vegetable oils, and it is to this property that I call particular attention. Chemistry will assign to this material, which has hitherto been comparatively neglected for feeding, a first place for the purpose of which I am treating. If objection should occur on account of its flavour, I have no difficulty in stating that by the preparation I have described I have quite overcome this. I can easily persuade my

cattle (of which 60 to 80 pass through my stalls in a year), without exception, to eat the requisite quantity. Nor is the flavour of the cake in the least perceptible in the milk or butter.

During May, my cows are turned out on a rich pasture near the homestead; towards evening they are again housed for the night, when they are supplied with a mess of the steamed mixture and a little hay each morning and evening. During June, when the grasses are better grown, mown grass is given to them instead of hay, and they are also allowed two feeds of steamed mixture. This treatment is continued till October, when they are again wholly housed.

The results which I now proceed to relate are derived from observations made with the view of enabling me to understand and regulate my own proceedings.

Gain or Loss of Condition ascertained by Weighing Cattle periodically.

For some years back I have regularly weighed my feeding stock, a practice from which I am enabled to ascertain their doings with greater accuracy than I could previously. In January, 1854, I commenced weighing my milch cows; it has been shown by what I have premised that no accurate estimate can be formed of the effect of the food on the production of milk, without ascertaining its effect on the condition of the cows. I have continued the practice once a month almost without omission up to this date. The weighings take place early in the morning, and before the cows are supplied with food; the weights are registered, and the length of time (15 months) during which I have observed this practice enables me to speak with confidence of the results.

The cows in full milk yielding 12 to 16 quarts each per day vary but little—some losing, others gaining, slightly; the balance in the month's weighing of this class being rather to gain. It is common for a cow to continue a yield from six to eight months before she gives below 12 quarts per day, at which time she has usually, if not invariably, gained weight.

The cows giving less than 12 quarts, and down to 5 quarts per day, are found when free from ailment to gain without exception. This gain, with an average yield of nearly 8 quarts per day, is at the rate of 7 lbs. to 8 lbs. per week each.

My cows in calf I weigh only in the incipient stages, but they gain perceptibly in condition, and consequently in value: they are milked till within four to five weeks previous to calving. I give the weights of three of these, and also of one heifer, which calved in March, 1855:—

No.		1854.	cwt.	qr.	lbs.	1855.	cwt.	qr.	lbs.	Gain. lbs.
1	Bought and weighed ..	July.	10	1	20	April	11	3	0	148
2	,, ,, ..	,,	8	2	10	,,	10	2	0	214
3	,, ,, ..	,,	8	2	0	,,	10	0	0	184
4	Heifer, which calved also in March, 1855, weighed	,,	7	0	0	,,	9	3	0	300

These observations extend over lengthened periods on the same animals, of from 30 to upwards of 50 weeks; a cow, free from calf and intended for fattening, continues to give milk from 10 months to a year after calving, and is then in a forward state of fatness, requiring but a few weeks to finish her for sale to the butchers.

It will thus appear that my endeavours to provide food adapted to the maintenance and improvement of my milch cows have been attended with success.

On examining the composition of the ordinary food which I have described, straw, roots, and hay, it appears to contain the nutritive properties which are found adequate to the *maintenance* of the animal, whereas the yield of milk has to be provided for by a supply of extra food; the rape-cake, bran, and bean-meal which I give will supply the albumen for the casein; it is somewhat deficient in oil for the butter, whilst it will supply in excess the phosphate of lime for a full yield of milk. If I take the class of cows giving less than 12 quarts per day, and taking also into account a gain of flesh, 7 to 9 lbs. per week, though I reduce the quantity of extra food by giving less of the bean-meal, yet the supply will be more in proportion than with a full yield; the surplus of nitrogen and phosphoric acid, or phosphate of lime, will go to enrich the manure.

I cannot here omit to remark on the satisfaction I derive from the effects of this treatment on the fertility of the land in my occupation. My rich pastures are not tending to impoverishment, but to increased fertility; their improvement in condition is apparent. A cow in full milk, giving 16 quarts per day, of the quality analysed by Haidlen, requires, beyond the food necessary for her maintenance, 6 to 8 lbs. per day of substances containing 30 or 25 per cent. of protein. A cow giving on the average 8 quarts per day, with which she gains 7 to 9 lbs. per week, requires 4 to 5 lbs. per day of substances rich in protein beyond the food which is necessary for her maintenance. Experience of fattening gives 2 lbs. per day, or 14 lbs. per week, as what can be attained on an average and for a length of time. If we consider ½ lb. per day as fat, which is not more than probable, there will be 1½ lb. for flesh, which, reckoned as dry mate-

rial, will be about ¼ lb.; which is assimilated in increase of fibrine and represents only 1½ to 2 lbs. of substances rich in protein beyond what is required for her maintenance.

If we examine the effects on the fertility of the land, my milch cows, when on rich pasture, and averaging a yield of nine quarts per day, and reckoning one cow to each acre, will carry off in 20 weeks 25 lbs. of nitrogen, equal to 30 of ammonia. The same quantity of milk will carry off 7 lbs. of phosphate of lime in 20 weeks from each acre.

A fattening animal gaining flesh at the rate I have described will carry off about one-third of the nitrogen (equal to about 10 lbs. of ammonia) abstracted by the milch cow, whilst if full grown it will restore the whole of the phosphate.

It is worthy of remark that experience states that rich pastures used for fattening, fully maintain their fertility through a long series of years; whilst those used for dairy cows require periodical dressings to preserve their fertility.

If these computations be at all accurate, they tend to show that too little attention has been given to the supply of substances rich in nitrogenous compounds in the food for our milch cows, whilst we have laid too much stress on this property in food for fattening cattle. They tend also to the inference that in the effects on the fertility of our pastures used for dairy purposes, we derive advantage not only from the phosphate of lime, but also from the gelatine of bones used as manure.

On comparing the results from my milch cows fed in summer on rich pasture, and treated at the same time with the extra food I have described, with the results when on winter food, and whilst wholly housed, taking into account both the yield of milk and the gain of weight, I find those from stall-feeding fully equal to those from depasture. The cows which I buy as strippers, for fattening, giving little milk, from neighbouring farmers who use ordinary food, such as turnips with straw or hay, when they come under my treatment, increase their yield of milk, until after a week or two they give two quarts per day more than when they came, and that too of a much richer quality.

Richness of Milk and Cream.

I sometimes observe in the weekly publications which come under my notice accounts of cows giving large quantities of butter; these are usually, however, extraordinary instances, and not accompanied with other statistical information requisite to their being taken as a guide; and it seldom happens that any allusion is made to the effects of the food on the condition of the animals, without which no accurate estimate can be arrived at. On looking over several treatises to which I have access, I find the following statistics on

dairy produce :—Mr. Morton, in his 'Cyclopædia of Agriculture,' p. 621, gives the results of the practice of a Mr. Young, an extensive dairy-keeper in Scotland. The yield of milk per cow is stated at 680 gallons per year; he obtains from 16 quarts of milk, 20 oz. of butter, or for the year, 227 lbs. per cow; from 1 gallon of cream 3 lbs. of butter, or 12 oz. per quart. Mr. Young is described as a high feeder; linseed is his chief auxiliary food for milch cows. Professor Johnston ('Elements of Agricultural Chemistry') gives the proportion of butter from milk at 1½ oz. per quart, or from 16 quarts 24 oz.; being the produce of four cows of different breeds—Alderney, Devon, and Ayrshire—on pasture, and in the height of the summer season. On other four cows of the Ayrshire breed he gives the proportion of butter from 16 quarts as 16 oz., being 1 oz. per quart. These cows were likewise on pasture. The same author states the yield of butter as one-fourth of the weight of cream, or about 10 oz. per quart. Mr. Rawlinson ('Journal of the Royal Agricultural Society,' vol. xiii., p. 38) gives the produce of 20,110 quarts of milk churned by hand as 1109 lbs. of butter, being at the rate of fully 14 oz. per 16 quarts of milk; and from 23,156 quarts of milk, 1525 lbs. of butter, being from 16 quarts nearly 16¾ oz. of butter. The same author states that the yield of butter derived from five churnings of 15 quarts of cream each is somewhat less than 8 oz. per quart of cream. Dr. Muspratt, in his work on the 'Chemistry of Arts and Manufactures,' which is in the course of publication, gives the yield of butter from a cow per year in Holstein and Lunenburg at 100 lbs., in England at 160 lbs. to 180 lbs. The average of butter from a cow in England is stated to be 8 oz. or 9 oz. per day, which, on a yield of 8 to 9 quarts, is 1 oz. per quart, or for 16 quarts 16 oz. The quantity of butter derived from cream is stated as one-fourth, which is equal to about 9 oz. per quart. The richest cream of which I find any record is that brought to the Royal Society's meeting during the month of July, for the churns which compete for the prize. On referring to the proceedings of several meetings, I find that 14 oz. per quart of cream is accounted a good yield.

I have frequently tested the yield of butter from a given quantity of my milk. My dairy produce is partly disposed of in new milk, partly in butter and old milk, so that it became a matter of business to ascertain by which mode it gave the best return. I may here remark that my dairy practice has been throughout on high feeding, though it has undergone several modifications. The mode of ascertaining the average yield of butter from milk has been to measure the milk on the churning day after the cream has been skimmed off, then to measure the cream, and having, by adding together the two measurements,

ascertained the whole quantity of milk (including the cream) to compare it with that of the butter obtained. This I consider a more accurate method than measuring the new milk, as there is a considerable escape of gas, and consequent subsidence, whilst it is cooling. The results have varied from 24 to 27¼ oz. from 16 quarts of milk. I therefore assume in my calculation 16 quarts of milk as yielding a roll (25 ounces) of butter.

As I have at times a considerable number of cows bought as strippers, and fattened as they are milked, which remain sometimes in my stalls eight or nine months, and yield towards the close but five quarts per day, I am not enabled to state with accuracy and from ascertained data the average yield per year of my cows kept for dairy purposes solely. However, from what occurs at grass-time, when the yield is not increased, and also from the effects of my treatment on cows which I buy, giving a small quantity, I am fully persuaded that my treatment induces a good yield of milk.

As the yield of butter from a given quantity of cream is not of such particular consequence, I have not given equal attention to ascertain their relative proportions. I have a recollection of having tested this on a former occasion, when I found 14 to 16 oz. per quart, but cannot call to mind under what treatment this took place.

On questioning my dairywoman, in December, 1854, as to the proportion of cream and butter, she reported nearly one roll of 25 oz. of butter to one quart of cream. I looked upon this as a mistake. On its accuracy being persisted in, the next churning was carefully observed, with a like proportion. My dairy cows averaged then a low range of milk as to quantity—about eight quarts each per day. Six of them, in a forward state of fatness, were intended to be dried for finishing off in January; but, owing to the scarcity and consequent dearness of calving cows, I kept them on in milk till I could purchase cows to replace them, and it was not till February that I had an opportunity of doing so. I then bought four cows within a few days of calving: they were but in inferior condition, and yielded largely of milk. Towards the close of February and March, four of my own dairy cows, in full condition, likewise calved. During March, three of the six which had continued from December, and were milked nearly up to the day of sale, were selected by the butcher as fit for his purpose. Each churning throughout was carefully observed, with a similar result, varying but little from 25 oz. of butter per quart of cream; on Monday, April 30, 16 quarts of cream having yielded 16 rolls (of 25 oz. each) of butter. Though I use artificial means of raising the temperature of my dairy, by the application of hot water during cold weather, yet, my service-pipes being frozen in

February, I was unable to keep up the temperature, and it fell to 45°. Still my cream, though slightly affected, was peculiarly rich, yielding 22 oz. of butter per quart. Throughout April the produce of milk from my 15 dairy cows averaged full 160 quarts per day.

My cows are bought in the neighbouring markets with a view to their usefulness and profitableness. The breeds of this district have a considerable admixture of the short-horn, which is not noted for the richness of its milk. It will be remarked that during the time these observations have been continued on the proportion of butter from cream, more than one-half of my cows have been changed.

Having satisfied myself that the peculiar richness of my cream was due mainly to the treatment of my cows, which I have sought to describe, it occurred to me that I ought not to keep it to myself; inasmuch as these results of my dairy practice not only afforded matter of interest to the farmer, but were fit subjects for the investigation of the physiologist and the chemist. Though my pretensions to acquirements in their instructions are but slender, they are such as enable me to acknowledge benefit in seeking to regulate my proceedings by their rules.

In taking off the cream I use an ordinary shallow skimmer of tin perforated with holes, through which any milk gathered in skimming escapes. It requires care to clear the cream; and even with this some streakiness is observable on the surface of the skimmed milk. The milk bowls are of glazed brown earthenware, common in this district; they stand on a base of 6 to 8 inches, and expand at the surface to nearly twice that width. Four to five quarts are contained in each bowl, the depth being 4 to 5 inches at the centre. The churn I use is a small wooden one, worked by hand, on what I believe to be the American principle. I obtained it from Messrs. Dray and Co. I have forwarded to Professor Way a small sample of butter for analysis; 15 quarts of cream were taken out of the cream jar, and churned at three times in equal portions—

The first five quarts of cream gave	127	oz. of butter.
The second five „ „	125	„
The third five „ „	120½	„
	372½	„

= to 24¾ oz. per quart.

At a subsequent churning of 14 quarts of cream—

The first seven gave 7 rolls, or	175	oz. of butter.
The second seven gave 7 rolls 2 oz., or ..	177	„
	352	„

= to 25¼ oz. per quart.

On testing the comparative yield of butter and of butter-milk, I find 70 per cent. of butter to 30 per cent. of butter-milk, thus reversing the proportions given in the publications to which I have referred. An analysis of my butter by Professor Way gives—

Pure fat or oil	82·70
Casein or curd	2·45
Water with a little salt	14·85
Total	100·00

The only analyses of this material which I find in the publications in my hand are two by Professor Way, 'Journal,' vol. xi. p. 735, "On butter by the common and by the Devonshire method;" the result in 100 parts being—

	Raw.	Scalded.
Pure butter	79·72	79·12
Casein, &c.	3·38	3·37
Water	16·90	17·51
Total	100·00	100·00

The foregoing observation of dairy results was continued up to grass time in 1855. In April and May the use of artificial means was discontinued without diminution in the yield of butter or richness of cream, the natural temperature being sufficient to maintain that of my dairy at 54° to 56°.

I now proceed to describe the appearances since that time. In the summer season, whilst my cows were grazing in the open pastures during the day and housed during the night, being supplied with a limited quantity of the steamed food each morning and evening, a marked change occurred in the quality of the milk and cream; the quantity of the latter somewhat increased, but instead of 25 oz. of butter per quart of cream, my summer cream yielded only 16 oz. per quart.

I would not be understood to attribute this variation in quality to the change of food only; it is commonly observed by dairy-keepers that milk during the warm months of summer is less rich in butter, owing probably to the greater restlessness of the cows, from being teased by flies, &c. I am by no means sure that, if turning out during the warm months be at all advisable, it would not be preferable that this should take place during the night instead of during the day time. Towards the close of September, when the temperature had become much cooler and the cows were supplied with a much larger quantity of the steamed food, results appeared very similar to those which I had observed and described from December to May, 1855. During the month of November the quality was tested with the following result.

From 252 qts. of old milk were taken 21 qts. of cream, of which 20 were churned, and produced 468 oz. of butter, which shows :—

27·50 oz. of butter for 16 qts. of new milk.
23·40 oz. „ each qt. of cream.

During May, 1856, my cows being on open pasture during the day were supplied with two full feeds of the steamed mixture, together with a supply of green rape-plant each morning and evening.

The result was that from 324 qts. of old milk 23 qts. of cream were skimmed, of which 22 were churned and produced 515 oz. of butter, which shows :—

24 oz. of butter from 16 qts. of new milk.
22·41 oz. „ each qt. of cream.

My food during the winter season 1855-56 has slightly varied from that of 1854-55. In October a respectable maltster in this village, who keeps dairy cows, asked me to purchase malt combs, of which he had a surplus. Having learnt from him on inquiry that from the use of them he obtained a larger yield of milk, without detriment to the condition of his cows. I was led to think that they contained a considerable per centage of albuminous matter. I took some on trial and forwarded a sample for analysis, which I supply, together with one of bran :—

Malt Combs.		*Bran.*	
Moisture	3·21	Moisture	12·85
Oil	2·96	Oil	5·56
Albuminous matter	23·87	Albuminous matter	13·80
Starch, sugar, &c.	45·94	Ash*	6·11
Woody fibre	18·80	Other constituents	61·68
Mineral matter	5·22		
J. T. Way.	100·00	Anderson.	100·00

* The ash contains 50 per cent. phosphoric acid.

I have used malt combs, together with bran, half and half, during the present season. Having a larger stock than the year before, with about an equal quantity of hay and less of roots, I reduced the allowance of the former from 12 lbs. to 9 lbs., and that of mangel from 36 lbs. to 28 lbs. per day. I gave also 1 lb. of rapecake additional to each, 6 lbs. in lieu of 5 lbs. On this fare, and with such changes of cows as were called for, my yield of milk, of which a register is kept, ranged during the months of October, November, December, and January, at 160 to 164 quarts per day from 18 cows, being fully 9 quarts per day from each cow. Their improvement in condition will appear from the following table :—

Stall A. 1855.	Weight. cwt.	qr.	lbs.	1856.	Weight. cwt.	qr.	lbs.				lbs.	Per Week. lbs.
1. Oct. 9,	10	3	0	Jan. 29	11	3	0	Gain in	16	weeks	112	7
2. Oct. 9,	9	3	0	„	9	3	0	„	„	„	„	„
3. Oct. 9,	10	1	0	„	11	0	0 C	„	„	„	84	5¼
4. Dec. 3,	10	0	0	„	10	0	12	„	8	„	12	1½
5. Jan. 1,	10	0	0	„	10	0	16 C	„	4	„	16	4
6. Oct. 9,	9	0	0	„	9	3	0	„	16	„	84	5¼
7. Oct. 9,	9	2	0	„	9	3	20 C	„	16	„	48	3

Stall B. 1855.	Weight. cwt.	qr.	lbs.	1856.	Weight. cwt.	qr.	lbs.				lbs.	Per Week. lbs.
1. Oct. 9,	11	1	0	Jan. 29,	12	2	20	Gain in	16	weeks	160	8¼
2. „	11	1	0	„	12	1	0	„	„	„	112	7
3. „		..		„	9	2	0	Newly calved.				
4. „	10	2	0	„	12	2	0	Gain in	16	weeks	224	14
5. „	9	2	0	„	10	0	8 C	„	„	„	64	4
6. „	11	0	0	„	11	3	0	„	„	„	84	5¼
7. Jan. 1,	9	2	0	„	9	3	0	„	4	„	28	7
8. Oct. 9,	10	1	0	„	11	1	0	„	16	„	112	7
9. Dec. 3,	11	1	0	„	11	2	0 C	„	8	„	28	3½
10. Oct. 9,	8	3	16	„	9	1	16 C	„	16	„	56	3½
11. „	9	3	0	„	10	3	16	„	16	„	128	8

The cows, No. 2 and No. 7, stall A, calved in September. Soon after calving each yielded 20 quarts per day. On their first weighing, No. 2 weighed 9 cwt. 3 qrs.; No. 7, 9 cwt. 2 qrs. At the next, No. 2 had lost 28 lbs.; No. 7 had exactly maintained its weight. On this being discovered, the attendant was ordered to give No. 2 a little bean-meal in addition. At the expiration of 16 weeks No. 2 gave 16 quarts, No. 7, 12 quarts per day; their respective weights were—No. 2, 9 cwt. 3 qrs., having regained her weight, and No. 7, 9 cwt. 3 qrs. 20 lbs. having gained 48 lbs. Eight weeks later, with a reduced yield of milk, No. 2 weighed 10 cwt., having gained 28 lbs.; No. 7, 104 lbs. from the time of calving. No. 2 was free from calf; No. 7 in the incipient stage of calf; five others, also marked C, were in like state of incipient calf.

No. 4, stall B, which shows the greatest gain, was far advanced in calf, giving but little milk.

Nos. 1, 2, 7, 8, and 11, in stall B, which had gained respectively 8¼ lbs., 7 lbs., 7 lbs., 7 lbs., 8 lbs. per week, were in course of fattening. I do not keep a separate account of the yield of each cow: the average yield of this class during the 16 weeks will have been about 8 quarts per day each; those gaining at a less rate per week—Nos. 4, 5, &c. in stall A, and 9, 10, &c. in stall B—may be reckoned as giving a greater yield of milk.

In February and March, 1856, four cows which had calved at the like period of 1855, were sold as fat for 19*l.* 15*s.* each; at the same time, in 1856, I bought cows of equal quality and capability, dry, or giving a small quantity of milk under ordinary treatment, at 11*l.* to 13*l.* each, to fatten which will require six months.

My cows thus fatted have the repute of killing well, and I am enabled to obtain the top price of the day; of the four sold in February and March, the purchasers have supplied me with the weights of loose fat.

Mr. Lupton, Burley,	150 lbs.	loose fat,	live weight	14 cwt.		
Mr. Wilson, Bradford,	152 ,,	,,	,,	12	,,	2 qr.
,, ,,	132 ,,	,,	,,	11	,,	1 ,,
,, ,,	90 ,,	,,	,,	11	,,	3 ,,

It will be observed that No. 2 stall A, with an average yield of milk of 18 quarts per day, maintained her weight during 16 weeks; whilst No. 7, with an average yield of 16 quarts per day, gained 48 lbs. in the like time. Taking Haidlen's analysis as a basis for calculation, the cow No. 2 will have given off in casein 2¼ lbs. per day, equal to 15¾ lbs. per week, which represents the albumen of 9 lbs. per day, or 63 lbs. per week, of feeding substances containing 25 per cent. of this matter. The bulky food I have described, straw, roots, and hay, with rape-cake 6 lbs., malt combs 1 lb., bran 1 lb., and bean-meal 2 lbs.—have sufficed for this, and have also maintained the weight or condition of the cow.

The six cows, giving 8 quarts of milk per day during 16 weeks, will have given off per day 1 lb. of dry casein, equal to 7 lbs. per week, and may have assimilated in dry fibrine 1 lb., equal to 4¼ lbs. of flesh; these together represent 5 lbs. per day, or 35 lbs. per week, of food containing 25 per cent. of albumen. As this class of animals have been supplied with 7 to 8 lbs. per day of such substances, it will be obvious that their excrement has been richer in nitrogen than that of No. 2.

If we allow a gain of weight of 16 lbs. per week, which is more than can be attained on the average by fattening, and reckon 12 of this as flesh or lean beef, equal to 2·70 per week, or ·39 per day, of dry fibrine, it will represent 1·56 lbs. per day, or 10·92 lbs. per week for what is assimilated in the fattening process beyond what is adequate for maintenance.

I adduce these calculations in corroboration of my proposition that food rich in albumen has a more especial value for the production of milk than for fattening or beef-making.

There is doubtless some standard of food adapted to the constitution and purposes of animals, combining with bulk a due proportion of elements of respiration, such as sugar, starch, &c., together with those of nutrition, viz., nitrogenous compounds, phosphates, and other minerals; nor can we omit oil or fat-forming substances; for however we may be disposed to leave to philosophy the discussion as to whether sugar, starch, &c. are convertible into fat, yet I think I shall not offend the teacher of Agricultural Chemistry by stating that the more closely the elements of food resemble those in the animal and its product,

the more efficacious will such food be for the particular purpose for which it is used.

Sugar, starch, &c., vary very considerably in form and proportion from vegetable oils, which closely resemble animal fats.

When we consider that plants have a two-fold function to perform, viz. to serve as food for animals and also for the reproduction of the like plants, and that after having undergone the process of digestion they retain only one-half or one-third of their value as manure, the importance of affording a *due but not excessive* supply of each element of food essential to the wants and purposes of the animal will be evident. If we fall short, the result will be imperfect; if we supply in excess, it will entail waste and loss.

Linseed and rape cake resemble each other very closely in chemical composition; the latter is chiefly used for manure, and its price ranges usually about half that of linseed cake. In substances poorer in nitrogen and with more of starch, gum, oil, &c., the disparity in value as food and as manure will be proportionately greater.

During the present season Mr. Mendelssohn, of Berlin, and Mr. Gausange, who is tenant of a large royal domain near Frankfort on the Oder, on which he keeps about 150 dairy cows, have been my visitors. These gentlemen have collected statistics in dairy countries through which they have travelled. I learnt from them that in Mecklenburg, Prussia, Holland, &c., 14 quarts of milk yield, on the average, 1 lb. of butter; in rare instances 12 quarts are found to yield 1 lb. Both attach great importance to the regulation of the temperature. Mr. Mendelssohn tells me that the milk from cows fed on draff (distiller's refuse) requires a higher temperature to induce its yield of butter than that from cows supplied with other food.

On inquiry in my own neighbourhood, I find it is computed that each quart at a milking represents 1 lb. of butter per week. Thus a cow which gives 4 quarts at each milking will yield in butter 4 lbs. per week, or from 56 quarts 64 oz. of butter, or from 14 quarts of milk 1 lb. of butter. Taking the winter produce alone, it is lower than this; the cream from my neighbours' cows, who use common food, hay, straw, and oats, somewhat resembles milk in consistency, and requires three to four hours, sometimes more, in churning. On one occasion a neighbouring dairywoman sent to borrow my churn, being unable to make butter with her own; I did not inquire the result. If she had sent her cow, I could in the course of a week have insured her cream which would make butter in half an hour. These dairy people usually churn during winter in their kitchen, or other room with a fire. Each of them states that from bean or oat meal used during winter

as an auxiliary food, they derive a greater quantity of butter, whilst those who have tried linseed-oil have perceived no benefit from it.

My own cream during the winter season is of the consistency of paste or thick treacle. When the jar is full, a rod of 2 feet long will, when dipped into the cream to half its length, stand erect. If I take out a teacup-full in the evening and let it stand till next morning, a penny piece laid on its surface will not sink; on taking it off I find the underside partially spotted with cream. The churnings are performed in a room without fire, at a temperature in winter of 43° to 45°, and occupy one-half to three-quarters of an hour.

Several who have adopted my system have reported similar effects—an increase in the quantity with a complete change as to richness of quality. I select from these Mr. John Simpson, a tenant farmer residing at Ripley, in Yorkshire, who at my request stated to the Committee of the Wharfdale Agricultural Society that he and a neighbour of his, being inconvenienced from a deficient yield of milk, had agreed to try my mode of feeding, and provided themselves with a steaming apparatus. This change of treatment took place in February, 1855. I quote his words:—

"In about five days I noticed a great change in my milk, the cows yielded 2 quarts each per day more, but what surprised me most was the change in the quality; instead of poor winter cream and butter, they assumed the appearance and character of rich summer produce, it only required 20 minutes for churning, instead of two to three hours; there was also a considerable increase in the quantity of butter, of which, however, I did not take any particular notice. My neighbour's cow gave 3 quarts per day in addition, and her milk was so changed in appearance that the consumers to whom he sold it became quite anxious to know the cause."

My dairy is but 6 feet wide by 15 long, and 12 high; at one end (to the north) is a trellis window, at the other an inner door which opens into the kitchen. There is another door near to this which opens into the churning-room, having also a northern aspect; both doors are near the south end of the dairy. Along each side, and the north end, two shelves of wood are fixed to the wall, the one 15 inches above the other; 2 feet higher is another shelf, somewhat narrower but of like length, which is covered with charcoal, whose properties as a deodoriser are sufficiently established. The lower shelves being 2 feet 3 inches wide, the interval or passage between is only 1 foot 6 inches. On each tier of shelves is a shallow wooden cistern lined with thin sheet-lead, having a rim at the edges 3 inches high. These cisterns incline downwards slightly towards the window, and contain water to the depth of 3 inches. At the end nearest the kitchen each tier of cisterns is supplied with two taps, one for cold water in summer, the other with hot for winter use. At the end

next the north window is a plug or hollow tube, with holes perforated at such an elevation as to take the water before it flows over the cistern.

During the summer the door towards the kitchen is closed, and an additional door is fixed against it, with an interval between well packed with straw; a curtain of stout calico hangs before the trellis window, which is dipped in salt-water, and kept wet during the whole day by cold water spurted over it from a gutta-percha tube. On the milk being brought in it is emptied into bowls. Some time after these bowls (of which a description is given in a former part of this) have been placed on the cistern, the cold-water taps are turned till the water rises through the perforated tube, and flows through a waste pipe into the sewer. The taps are then closed, so as to allow a slight trickling of water, which continues through the day. By these means I reduce the temperature, as compared with that outside the window, by 20°. I am thus enabled to allow the milk to stand till the cream has risen, and keep the skimmed milk sweet, for which I obtain 1*d.* per quart.

Having heard complaints during very hot weather of skimmed milk, which had left my dairy perfectly sweet, being affected so as to curdle in cooking on being carried into the village, I caused covers of thick calico (the best of our fabrics for retaining moisture) to be made; these are dipped in salt-water and then drawn over the whole of the tin milk cans: the contrivance is quite successful, and is in great favour with the consumers. I have not heard a single complaint since I adopted it.

Finding my butter rather soft in hot weather I uncovered a draw-well, which I had not used since I introduced waterworks for the supply of the village and my own premises. On lowering a thermometer down the well to a depth of 28 feet, I found it indicated a temperature of 43°—that on the surface being 70°. I first let down the butter, which was somewhat improved, but afterwards the cream; for this purpose I procured a moveable windlass, with a rope of the required length; the cream-jar is placed in a basket 2 feet 4 inches deep, suspended on the rope, and let down the evening previous to churning. It is drawn up early next morning and immediately churned; by this means the churning occupies about the same time as in winter, and the butter is of like consistency.

The advantage I derive from this is such that, rather than be without it, I should prefer sinking a well for the purpose of reaching a like temperature.

When winter approaches, the open trellis window to the north is closed, an additional shutter being fixed outside, and the inter-

val between this and an inner shutter closely packed with straw to prevent the access of air and cold; the door to the kitchen is at the same time unclosed to admit warmth. Before the milk is brought from the cowhouse the dairymaid washes the bowls well with hot water, the effect of which is to take off the chill but not to warm them; the milk is brought in as milked, and is passed through a sile into the bowls, which are then placed on the cistern. A thermometer, with its bulb immersed in the milk, denotes a temperature of about 90°. The hot water is applied immediately at a temperature of 100° or upwards, and continues to flow for about five minutes, when the supply is exhausted. The bowls being of thick earthenware—a slow conductor—this does not heighten the temperature of the milk. The cooling, however, is thereby retarded, as I find the milk, after standing four hours, maintains a temperature of 60°. This application of hot water is renewed at each milking to the new milk, but not repeated to the same after it has cooled. The temperature of the dairy is momentarily increased to above 60°, but speedily subsides, the average temperature being 52° to 56°.

It will be observed that the churnings in summer and winter occupy half an hour or upwards; by increasing the temperature of the cream I could easily churn in half the time, but I should thereby injure the quality of the butter. When the butter has come, and gathered into a mass, it is taken, together with the buttermilk, out of the churn, which is rinced with water; the butter is then placed again in the churn, with a quantity of cold spring water in which salt has been dissolved, at the rate of 1 oz. per quart of cream; after a few minutes' churning, the butter is again taken out; the water in which it has been washed assumes a whitish appearance. By this process the salt is equally diffused through the butter, which requires little manipulation, and is freed from a portion of caseous matter. A recent analysis of my butter shows only 1·07 instead of 2·45 per cent. of casein, as before; that it ranks as choice may be inferred, when I state that my purchaser willingly gives me 1*d.* per roll more than the highest price in Otley market, and complains that I do not supply him with a greater quantity.

In this dairy, of the small dimensions I have described, my produce of butter reaches at times 60 to 70 lbs. per week. Though the size may appear inconveniently small, yet I beg to remark on the greater facility of regulating the temperature of a small in comparison with a large dairy. This difficulty will be found greater in summer than in winter, as it is far easier to heighten than depress the temperature.

I have cooked or steamed my food for several years. It will be observed that I blend bean-straw, bran and malt combs, as

flavouring materials, with oat or other straw and rape-cake: the effect of steaming is to volatilise the essential oils, in which the flavour resides, and diffuse them through the mess. The odour arising from it resembles that observed from the process of malting: this imparts relish to the mess, and induces the cattle to eat it greedily; in addition to which I am disposed to think that it renders the food more easy of digestion and assimilation. I use this process with advantage for fattening, when I am deficient in roots. With the same mixed straw and oat-shells, 3 to 4 lbs. each of rape-cake, and ½ lb. of linseed oil, but without roots, I have fattened more than 30 heifers and cows free from milk, from March up to the early part of May; their gain has averaged fully 14 lbs. each per week—a result I could not have looked for from the same materials if uncooked; this process seems to have the effect of rendering linseed oil less of a laxative, but cannot drive off any portion of the fattening oils, to volatilise which requires a very high temperature. My experience of the benefits of steaming is such, that if I were deprived of it I could not continue to feed with satisfaction.

I have weighed my fattening cattle for a number of years, and my milch cows for more than two years; this practice enables me at once to detect any deficiency in the performance of the animals; it gives also a stimulus to the feeders, who attend at the weighings, and who are desirous that the cattle entrusted to their care should bear a comparison with their rivals. Another obvious advantage is in avoiding all cavils respecting the weight by my purchasers, who, having satisfied themselves as to the quality of the animal, now ask and obtain the most recent weighing. The usual computation for a well-fed, but not over fat beast, is, live to dead weight as 21 to 12, or 100 to 59 1-7th, with such modifications as suggest themselves by appearances.

Though many discussions have taken place on the fattening of cattle, the not less important branch of dairy treatment has hitherto been comparatively neglected. I therefore venture to call attention to considerations which have arisen from observations in my own practice, affecting the chemistry and physiology, or, in other words, the science of feeding. That I am seeking aid from its guidance will be apparent, and I have no hesitation in admitting, that beyond the satisfaction from the better understanding of my business, I have latterly derived more benefit or profit from examination of the chemical composition of materials of food than from the treatment or feeding experiments of others which have come under my notice. So persuaded am I of the advantage of this, that I do not feel satisfied to continue the use of any material, with the composition of which I am not acquainted, without resorting to the Society's Laboratory for an analysis.

To one leading feature of my practice I attach the greatest importance—the maintenance of the condition of my cows, giving a large yield of milk. I am enabled, by the addition of bean-meal in proportion to the greater yield of milk, to avert the loss of condition in those giving 16 to 18 quarts per day; whilst on those giving a less yield and in health, I invariably effect an improvement. Nos. 2 and 7, in stall A, may be regarded as ordinary results from my treatment.

When we take into consideration the disposition of a cow to apply her food rather to her milk than to her maintenance and improvement, it seems fair to infer that the milk of a cow gaining flesh will not be deficient either in casein or butter.

I have already alluded to the efficiency of bean-meal in increasing the quantity of butter; I learn also, from observant dairymen who milk their own cows and carry their butter to market, that their baskets are never so well filled as when their cows feed on green clover, which, as dry material, is nearly as rich in albumen as beans; I am also told, by those who have used green rape plant, that it produces milk rich in butter. From this we may infer that albuminous matter is the most essential element in the food of the milch-cow, and that any deficiency in the supply of this will be attended with loss of condition, and a consequent diminution in the quality of her milk.

I am clearly of opinion that you can increase the proportion of butter in milk more than that of casein, or other solid parts. From several, who have adopted my treatment, I learn that on substituting rape-cake for beans they perceive an increased richness in their milk. Mr. T. Garnett, of Clitheroe, who has used bean-meal largely as an auxiliary food for milch-cows during the winter season, tells me that when rape-cake is substituted, his dairymaid, without being informed, perceives the change from the increased richness of the milk. Mr. Garnett has also used linseed-cake in like quantity, still his dairy people prefer rape-cake.

Mr. Whelon, of Lancaster, who keeps two milch cows for his own use, to which he gave bean-meal and bran as auxiliaries, has recently substituted rape-cake for bean-meal; he informs me that in a week he perceived a change in the richness of the milk, with an increase of butter.

The vegetable oils are of two distinct classes: the *drying* or *setting* represented by linseed, the *unctuous* represented by rape-oil. They consist of two proximate elements, margerine and olein; in all probability they will vary in their proportion of these, but in what degree I have not been able to ascertain. Though the agricultural chemists make no distinction, as far as I am aware, between these two classes of oils, the practitioners

in medicine use them for distinct purposes. Cod-liver oil has been long used for pulmonary complaints; latterly, olive, almond, and rape-oils are being employed as substitutes. These are all of the unctuous class of oils. Mr. Rhind, the intelligent medical practitioner of this village, called my attention to some experiments by Dr. Leared, published in the 'Medical Times,' July 21st, 1855, with olein alone, freed from margerine, which showed marked superiority in the effect; and I now learn from Mr. Rhind that he is at present using with success the pure olein, prepared by Messrs. Price and Co. from cocoa-nut oil, one of the unctuous class. That linseed, and others of the drying-oils, are used in medicine for a very different purpose, it seems unnecessary to state.

The olein of oil is known to be more easy of consumption and more available for respiration than margerine—a property to which its use in medicine may be attributable.* If we examine the animal fats, tallow, suet, and other fat, they are almost wholly of the solid class, stearine or margerine, closely resembling or identical with the margerine in plants; whilst butter is composed of olein and margerine, combining both the proximate elements found in vegetable oils.

It seems worthy of remark that a cow can yield a far greater weight of butter than she can store up in solid fat; numerous instances occur where a cow gives off 2 lbs. of butter per day, or 14 lbs. per week, whilst half that quantity will probably rarely be laid on in fat. If you allow a cow to gain 16 lbs. per week, and reckon 7 for fat, there will only remain 9 lbs. for flesh, or, deducting the moisture, scarcely 3 lbs. (2·97) per week, equal to ·42, or less than half a pound per day, of dry fibrine.

The analyses of butter show a very varying proportion of olein and margerine fats: summer butter usually contains of olein 60, and margerine 40 per cent, whilst in winter butter these proportions are reversed, being 40 of olein to 60 of margerine. By ordinary treatment the quantity of butter during winter is markedly inferior; the common materials for dairy-cows in winter are straw with turnips or mangel, hay alone, or hay with mangel. If we examine these materials, we find them deficient in oil, or in starch, sugar, &c. If a cow consume 2 stones or 28 lbs. of hay a day, which is probably more than she can be induced to eat on an average, it will be equal in dry material to more than 100 lbs. of young grass, which will also satisfy a cow. That 100 lbs. of young grass will yield more butter will scarcely admit of a doubt. The 28 lbs. of hay will be equal in albuminous matter and in oil to the 100 lbs. of grass,

* See 'Lehman's Physiological Chemistry.'

but in the element of starch, sugar, &c., there is a marked difference. During the growth of the plant, the starch and sugar are converted into woody fibre, in which form they are scarcely digestible or available for respiration. It seems, then, not improbable that, when a cow is supplied with hay only, she will consume some portion of the olein oil for respiration, and yield a less quantity of butter poorer in olein.

If you assume summer butter to contain of olein ..	60	per cent.
" " of margerine	40	"
	100	"
If the cow consume of the olein	36	"
The quantity of butter will be reduced from 100 to	64	"
And the proportions will then be, of olein	40	"
of margerine ..	60	"
	100	

If you supply turnips or mangel with hay, the cow will consume less of hay; you thereby substitute a material richer in sugar, &c., and poorer in oil. Each of these materials in the quantity a cow can consume is deficient in the supply of albumen necessary to keep up the condition of an animal giving a full yield of milk. To effect this recourse must be had to artificial or concentrated substances of food, rich in albuminous matter.

It can scarcely be expected, nor is it desirable that practical farmers should apply themselves to the attainment of proficiency in the art of chemical investigations; this is more properly the occupation of the professor of science. The following simple experiment, however, seems worth mentioning. On several occasions, during winter, I procured samples of butter from my next neighbour; on placing these, with a like quantity of my own, in juxtaposition before the fire, my butter melted with far greater rapidity—by no means an unsafe test of a greater proportion of olein.

The chemical investigation of our natural and other grasses has hitherto scarcely had the attention which it deserves. The most valuable information on this subject is in the paper by Professor Way on the nutritive and fattening properties of the grasses in Vol. XIV., p. 171, of the Royal Agricultural Society's Journal. These grasses were nearly all analyzed at the flowering time, a stage at which no occupier of grass-land would expect so favourable a result in fattening. We much prefer pastures with young grass not more than a few inches high, sufficient to afford a good bite. With a view to satisfy myself as to the difference of composition of the like grasses at different stages of growth, I

sent to Professor Way a specimen of the first crop of hay, cut in the end of June, when the grass was in the early stage of flowering, and one of aftermath, cut, towards the close of September, from the same meadow, the analyses of which I give:—

Hay, First Crop.		*Aftermath Hay.*	
Moisture	12·02	Moisture	11·87
Albuminous matter	9·24	Oil and fatty matter	6·84
Oil and fatty matter	2·68	Albuminous matter	9·84
Starch, gum, sugar	39·75	Starch, gum, sugar	42·25
Woody fibre	27·41	Woody fibre	19·77
Mineral Matter	8·90	Mineral matter	9·43
	100·00		100·00

A comparison between these will show a much greater percentage of woody fibre, 27·41 in the first crop to 19·77 in the aftermath. The most remarkable difference, however, is in the proportion of oil, being 2·68 in the first crop to 6·84 in the aftermath.

On inquiry from an observant tenant of a small dairy-farm of mine, who has frequently used aftermath hay, I learn that, as compared with the first crop, he finds it induce a greater yield of milk, but attended with some impoverishment in the condition of the cow, and that he uses it without addition of turnips or other roots, which he gives when using hay of the first crop—an answer quite in accordance with what might be expected from its chemical composition.

It is likewise to be presumed that the quickness of growth will materially affect the composition of grasses, as well as of other vegetables. Your gardener will tell you that if radishes are slow in growth they will be tough and woody, that asparagus melts in eating like butter, and salad is crisp when grown quickly. The same effect will, I apprehend, be found in grasses of slow growth: they will contain more of woody fibre, with less of starch or sugar. The quality of butter grown on poor pastures is characterised by greater solidity than on rich-feeding pastures, the cows having to travel over more space require a greater supply of the elements of respiration, whilst the grasses grown on these poor pastures contain, in all probability, less of these in a *digestible form* available for respiration. The like result seems probable as from common winter treatment—a produce of butter less in quantity, and containing a greater proportion of margerine, and a less of olein.

It is well known that pastures vary greatly in their butter-producing properties; there is, however, as far as I am aware, no satisfactory explanation of this. If you watch cows on depasture, you observe them select their own food; if you supply

cows in stall alike with food, they will also select for themselves. I give rape-cake as a mixture to all, and induce them to eat the requisite quantity; yet some will select the rape-cake first, and eat it up clean, whilst others rather neglect it till towards the close of their meal, and then leave pieces in the trough. Two Alderneys—the only cows of the kind I have as yet had—whose butter-producing qualities are well known, are particularly fond of rape-cake, and never leave a morsel; may not these animals be prompted by their instinct to select such food as is best suited to their wants and propensities? If so, it seems of the greatest importance that the dairyman should be informed of the properties of food most suitable for his purpose, especially whilst in a stall, where they have little opportunity of selecting.

It appears worth the attention of our Society to make inquiries as to the localities which are known as producing milk peculiarly rich in butter. When travelling in Germany I well recollect being treated with peculiarly rich milk, cream, and butter on my tour between Dresden and Toplitz, at the station or resting-place, on the chaussée or turnpike-road, before you descend a very steep incline to the valley in which Toplitz is situated. I travelled this way after an interval of several years, when the same treat was again offered. It was given as a rarity, and can only be accounted for by the peculiar adaptation of the herbage of the country for the production of butter.

Burley Hall, Yorkshire, May, 1856.

P.S. *June 7th*, 1856.—Having had occasion to visit London I called upon J. F. Wilson, director of Messrs. Price's manufactory at Belmont. In addition to other interesting information in regard to the properties of fats, Mr. Wilson kindly supplied me with a Treatise on Oils, by Jules de Fontenelle à Paris, from which I supply the following particulars:—

	Reaumur.		Olein.	Stearine.
Olive-oil congeals (solidifies) at a temperature of	+ 2	=	72	28
Rape-oil " "	− 5	=	54	46
Linseed-oil " "	−22	No analysis.		

Olive-oil is by far the richest in olein, which accounts for its extended use in cooking, more especially on the continent, where it is a principal ingredient in culinary preparations.

The analysis of rape-oil corresponds precisely in its proportion of olein and margerine with that of butter of fair quality.

Jules de Fontenelle very properly observes that an analysis of each of the vegetable oils could not fail to be of the greatest interest.

I may add that we agriculturists have a claim on our professors of chemistry to give their attention to like investigations.

X.—*On some points in Agricultural Chemistry.* By JUSTUS VON LIEBIG.

In the years 1840 and 1842 I expressed the opinion that the natural sources of the nitrogen necessary to plants are not sufficient for the requirements of agriculture. But a series of observations, as well as continued reflection on the subject, convinced me that this opinion could not be maintained.

As my work on Agricultural Chemistry contains only a very small part of the experience and of the facts on which my conclusions are founded, I propose in the following pages to enter more minutely into some of these details; and I entertain the hope that every reader will acquire the conviction that the considerations which induced me, in 1843 (when the 3rd edition of my 'Chemistry, in its application to Agriculture and Physiology' appeared), to give up the views above alluded to, which I had previously entertained, are simple and incontrovertible.

From a given surface of land we reap, in different cultivated crops, according to the analyses which have been made, very unequal quantities of nitrogen. If we assume that the amount of nitrogen, reaped from an acre of land in the form of grain and straw, is, in the case of rye, represented by 100 parts by weight, then the same surface, one acre, yields of nitrogen—

In Oats	114 parts.
Barley	116 „
Wheat	118 „
Meadow hay	121 „
Rape	212 „
Peas	243 „
Beans	270 „
Clover	390 „
Turnips	470 „

These numbers prove incontestably that peas, beans, and the other fodder or green crops, yield more nitrogen than the grain crops. Meadow hay yields about as much as grain, or a little more; but peas, beans, and clover, supply twice as much nitrogen as wheat. These crops—peas, beans, and clover—yield this increased amount of nitrogen, *without the use of nitrogenised manure.* Nay, the produce of nitrogen can be even augmented still further: in clover by the use of ashes and of gypsum; in turnips by the addition of superphosphate of lime.

The source from which these crops obtain the nitrogen they contain can be no other than the atmosphere.

In practical cultivation, it is to grain fields that nitrogenised manures are especially given. It is plain that the necessity for supplying nitrogen to grain crops, such as wheat for instance,

cannot be explained by supposing the natural sources of nitrogen to be incapable of supplying to these plants *enough of nitrogen* for a full crop, because the cultivation of green crops proves that these natural sources can supply from twice to four times as much nitrogen as is required for a full crop of wheat. We must seek elsewhere, in other relations, for the true reason of this necessity.

The views on this subject, to which I was led in 1843, were not a little fortified when, in 1846, by means of the analyses of twenty-two soils which I caused to be made in my laboratory in Giessen by Dr. Kroker, now Professor in Breslau, I acquired the conviction that one acre of the most unfruitful soil, taken to the depth of only 10 inches, contains more than a hundred times, and one acre of fertile soil as much as from five hundred to a thousand times, more nitrogen than is required for the heaviest crop of wheat, or than is given to it in the most liberal supply of manure. (See my 'Agricultural Chemistry,' 4th edition, p. 275.)

The fact of the presence of this enormous amount of nitrogen in the soil has been confirmed by the researches made at the instance of the Royal College of Rural Economy in Berlin ('Annalen der Landwirthschaft,' vol. xiv. p. 2). The College of Rural Economy caused land of apparently uniform quality to be selected in fourteen different localities in Prussia for these experiments. At ten or twelve different points of each of these fields an equal quantity of earth was taken by the spade from the entire depth of the arable soil; these portions, in each case, were thoroughly mixed, and from the mass samples were taken.

In each sample the amount of nitrogen was determined *by three different chemists separately*, and from their results have been calculated for one acre of land, to the depth of one foot (the specific gravity of the soil being taken at 1·5), the following quantities of nitrogen, expressed however in pounds of *ammonia* (17 lbs. of ammonia contain 14 lbs. of nitrogen):—

No.	Locality.	Lbs. of Ammonia.
1.	Soil from Havixbec	18,040
2.	" Burgwegeleben	17,220
3.	" Turgaitschen	14,350
4.	" Wallup	13,120
5.	" Beesdau	7,790
6.	" Turwe	7,380
7.	" Dalheim	6,970
8.	" Laasom	5,740
9.	" Eldena	5,330
10.	" Burgbornheim	5,330
11.	" Neuenmund	4,510
12.	" Frankenfeld	4,100
13.	" Neuhof	4,920
14.	" Cartlon	2,870

To these determinations may be added the analysis of the Russian black earth (tscherno-sem), in the government of Orel, for which we are indebted to M. E. Schmid ('Petersburger Academisches Bulletin,' vol. viii. p. 161).

Schmid examined three samples of virgin soil, on which no crop had ever been cultivated, and a sample of unmanured arable land. (The density, or specific gravity of these soils, was found to be from 2·1 to 2·2; but, on account of the porosity of soils, I have not thought it necessary to estimate it higher than 1·5.) From Schmid's results it appears that one acre, to the depth of one foot, of these four samples contains the following quantities of ammonia:—

No.	Russian Black Earth.	Lbs. Ammonia.
1.	Upper stratum	49,200
2.	Four werschock deeper	22,140
3.	Subsoil	20,000
4.	Unmanured arable land	23,780

In regard to the amount of ammonia, the following soils in Munich, which I have analysed with a view to this subject, approach very nearly to the Russian black earth:—

No.	Soils in Munich.	Lbs. Ammonia.
1.	From the garden of my house	22,960
2.	From the neighbouring Botanic Garden ..	21,730
3.	From a wood in the vicinity	20,910

Lastly, by the kindness of M. Schlossberger, in Havannah, I have obtained six different samples of soils from the island of Cuba, in which tobacco is grown (the crop which is richest in nitrogen), and which have never been manured. These soils contain, in one acre of soil, to the depth of 12 inches—

No.	Lbs. Ammonia.
1.	9,020
2.	12,300
3.	1,640
4.	9,344
5.	14,350
6.	10,250

The source of all this nitrogen is easily pointed out. In my work (pp. 57, 96, 115, &c.) I have shown that clay, alumina, and peroxide of iron, all of which are present in the most fertile soils, possess a most remarkable power of absorbing ammonia from the air, and that all fertile soils contain a certain amount of ammonia derived from the atmosphere.

It is easy to form an idea of the quantity of ammonia which the soil can take up from this source if we remember the experiments of Thomas Way, who found ('Journal of the Royal Agricultural Society,' vol. xiii. p. 126) that 100,000 parts, by

weight, of a thin soil from Dorsetshire, absorbed and retained in a very fixed and permanent form of combination, on an average of four experiments, 348 parts, by weight, of ammonia, and that the same weight of a light red soil from Berkshire absorbed 157 parts; the same weight of a stiff white clay 282 parts, by weight, of ammonia.

If we now calculate how much ammonia one acre of each of these soils can take up to the depth of 12 inches, in addition to that already contained in it from long exposure to the air, taking the specific gravity at 1·5, we find that—

	Lbs. Ammonia.
One acre of the thin land of Dorsetshire can take up ..	20,880
" light red soil, Berkshire	9,420
" stiff white clay	17,040

These numbers express, not how much ammonia the soils contain, but how much they are still capable of absorbing from the air and from the rain, in addition to what was already present. They express the power of absorption of these soils for ammonia; and this can even be increased by ploughing or digging and by draining, which allow an easier access to the air and to the rain.

The fact that the soil contains enormous quantities of ammonia, derived from the atmosphere, was thus known with certainty. But the discovery that the soil can remove from rain-water the ammonia dissolved in it, belongs to Thomas Way.* I regard this as a very important discovery, which satisfactorily explains the gradual accumulations of large quantities of ammonia in cultivated soils.

I have ascertained by a series of experiments ('Annalen des Chemie and Pharmacie,' vol. 94), that the very calcareous soil near Munich possesses, in an equal degree with clay soils or clay, the power of removing ammonia from water. This calcareous soil contains, I may state here, invariably nitrates, which are almost entirely absent from clay soils. Even the calcareous soil of Cuba, on which tobacco is grown and which has never been manured, contains large quantities of nitric acid.

If my conclusions of 1843 be considered along with the determinations of the amount of ammonia in arable soil, which I caused to be made in 1846, it is easy to see how I felt myself compelled

* This fact was first ascertained by me in the course of some experiments undertaken for the express purpose of ascertaining the comparative loss of ammonia sustained by the washing of rain after manuring soils with different salts of ammonia, especially the carbonate and sulphate. The analyses were performed by that very accurate chemist Mr. Spence of York, and showed unmistakeably the great affinity of almost any cultivated soil for ammonia. These experiments were made more than two years before the commencement of Mr. Way's investigation. A brief account of them is given in this Journal, vol. xi. p. 68.—H. S. T.

to relinquish the views I entertained at a period previous to 1843. These analyses of soils, as well as those made in Prussia, in Russia, and, at a still later period, again by myself, prove in the most incontestable manner that the fundamental proposition of Messrs. Lawes and Gilbert, namely, "*that the quantities of nitrogen which are supplied to plants by the natural sources of that element do not suffice for the requirements of a full crop of wheat*," has no foundation whatever. These natural sources supply the wheat plant with a hundred times, nay often a thousand times, more nitrogen than it requires for the fullest development.

It follows inevitably that all the conclusions which these gentlemen have established on this fundamental proposition are erroneous, and cannot be maintained.

It follows further that all the experience and all the facts which they endeavoured to refute, by means of this fundamental proposition, and which they believed themselves to have refuted, have not been refuted, and must, in the mean time, be maintained.

In my book I have expressed the opinion that the soil of a country cannot, by means of cultivation, be exhausted of nitrogen, because nitrogen is not a true constituent of the soil, but a constituent of the atmosphere. It is only lent to the soil; and what the soil loses in nitrogen at one point is restored to it by the air, which is everywhere: consequently the exhaustion or loss of fertility of our fields cannot depend on a deficiency of nitrogen.

I have been led to this opinion by the consideration of the cultivation of entire countries or districts (such as the Valley of the Nile, Switzerland, Holland); and the same considerations, if applied to things nearer home, will probably convey to all who attend to them a full conviction of the truth of the opinion to which I have referred.

From the daily consumption of food Messrs. Lawes and Gilbert calculate that the 2½ millions of inhabitants of London ('Journal of the Society of Arts,' vol. iii. p. 272) annually consume upwards of 25½ millions of pounds of nitrogen; and the composition of their solid and liquid excreta proves that in these last upwards of 17 millions of pounds of nitrogen, chiefly in the form of ammonia, are conveyed to the sea, while the greater part of the remainder returns to the atmosphere. This estimate is rather under than over the truth. In Liverpool, Newcastle, Bristol, Dublin, Glasgow, and all the large and small towns of Great Britain, the state of matters is precisely the same.

If it were possible for a man to rise to such a height as to survey at one glance the entire British Isles, this man, if the ammonia were visible, would perceive that a mighty stream or current of nitrogen flows daily from the land to the sea and the atmosphere, amounting in a year to 2 million of cwts.; that what is

added to the land in the forms of manure from cattle, corn, and guano (I assume annually 100,000 tons of guano, with an average of 4·5 per cent. of nitrogen), does not make up one-third part of this loss; and that the loss increases annually with the increase of population. Previous to 1840 our supposed observer would have seen, to his amazement, that Great Britain only received, to make up for the constant loss of nitrogen, a still smaller fraction of the lost nitrogen, and that, in spite of this, the fertility and productiveness of the English soil not only was not diminished, but has uniformly increased for centuries past; nay, that the supply of nitrogenised manure in the dung-heaps of English farmers has been augmented.

All the nitrogen of plants and of animals is derived from the air. Every fireplace where coals are burned, the numerous furnaces and chimneys of the manufacturing towns and districts, of locomotive engines and steam-ships, all the smelting furnaces of the iron-works—all these are so many forms of distillatory apparatus which enrich the atmosphere with the nitrogenised food of a vegetable world belonging to a period long past. We can form some idea of the quantities of ammonia thus poured into the atmosphere if we consider that in numerous gas-works many tons of ammoniacal salts are annually obtained from the coals distilled for gas.

In other words, if all the nitrogen or all the ammonia which Great Britain sends into the sea and the air from her towns and fields, and which is thus lost to her, had been exported, not as ammonia, but in the forms of cattle and corn, in her ships, for centuries past, she would not be poorer in nitrogen by a single pound than she now is. No doubt she might have been richer in nitrogen had this loss not taken place; but she could not have been poorer than she now is, because, in consequence of the cultivation of her soil, the nitrogen lost by the land in the forms of cattle and corn is restored to it by the atmosphere, which is everywhere, and conveys its benefits to every spot—which leaves the place where it has yielded nitrogen to the soil for another where it is again supplied with that substance.

But if the soil of a country cannot lose its fertility by the loss of ammonia, the question remains, whether its fertility can be increased by the addition of *ammonia alone?* that is, whether the soil by this means can acquire the power of producing, in a series of years, say in fifty years, more corn and more cattle than it would have produced in the same period without this addition?

The answer to this question is obvious, if we inquire *on what the fertility of our soil, on what its augmented produce, and on what the continuance of this augmentation of produce depend.* But before I enter more minutely into these questions, I must beg

permission to premise some historical notices, in order to define accurately the point of view from which my book was written.

"It must be remembered (see 2nd edition, p. vii.) that the object of the author was not to write a system of agricultural chemistry, but to furnish a treatise on the chemistry of agriculture." In all the subsequent editions the book has retained this character; the distinction above pointed out is self-evident.

A system of agricultural chemistry contains the theory and its application to practical agriculture; in my book, on the contrary, the object of which was chemistry in its application to agriculture, the principles of chemistry are laid down, and the chemical conditions of cultivation, with the chemical processes or changes concerned, are explained and developed. A system of agricultural chemistry can only be written by a practical agriculturist, who knows the universal experience of agriculturists. Such a work must contain the rules for the preparation of the soil, for the manuring of the different crops, as of wheat, or of turnips, with their succession; but the chemistry of agriculture endeavours to harmonize the experience of farmers with natural laws, or with known and established truths. "The purpose of this work is to elucidate the chemical processes concerned in the nutrition of vegetables." (p. 3.)

Compared with a system of agricultural chemistry, my book appears a work altogether deficient in arrangement and full of the strangest contradictions: while on one page the advantage derived from ammonia is proclaimed, and it is most urgently recommended to the farmer to collect with the utmost care the ammonia of his manure, and to apply it to his fields, the best means being indicated for avoiding any loss of this substance; it is stated on another page, that plants obtain all their nitrogen from the atmosphere, and that the nitrogen of the manure, considered by itself as a part of the food of plants, hardly contributes to increase the produce of the crop. There is here no advice to the farmer as to what he ought to do in order to obtain from his soil a maximum of produce in the way most profitable for himself. No one can find here any statement as to whether ammonia should or should not be given in the manure, to wheat, or to what other crop soever; for in the Vocabulary of Science the word *Profit* does not exist.

All these apparent contradictions are explained, when we place ourselves, and this an author is entitled to insist upon, at the point of view of the writer, and make up our minds to follow him in his reasoning with some degree of attention.

The most distinguished agriculturists (such as Schwerz and Thaer), the greatest chemists and men of science (Berzelius, Gay Lussac, Boussingault, Payen, De Saussure), believed, up to

the period of the publication of my book, that the fertility of soils and the effect of manure depended exclusively on the presence in them, and on the amount, of humus or of organic substances.

"The effects of organic manure are wonderful and incomprehensible," says Schwerz (*Handbüch des Sprachlischen Akerbaues*, vol. iii. p. 33); "this is the Gordian knot which cannot be unloosed; it is the limit of natural science, beyond which Isis covers all with the veil of mystery." "It is the vegetable and animal extracts (*Bibliothèque Universelle*, vol. xxxvi.) which determine the agricultural value of the soil."

"Plants," says Berzelius (*Handbuch*, 1839, p. 77), "obtain the material for their growth from the earth and the air, which are both alike indispensable to them. The earthy part appears to exert on plants no other influence except only a mechanical one."

Further (vol. viii. p. 423): "Lime serves, partly as a stimulant, partly as a chemical agent, by which the constituents of the arable soil or mould are rendered soluble in water: hence we cannot call liming a manure. Another influence of liming or of the alkalies in ashes, consists in this, that by their agency the organic constituents of the soil are more rapidly converted into humus. It is not known in what way gypsum acts in producing the good effects which experience shows it to produce." Further (vol. vi. p. 101): "We have seen, from what has been said, how plants assimilate carbon and oxygen; but we have not found whence they procure the hydrogen, or the nitrogen, which certain parts of plants contain in notable proportion." (*Berzelius.*)

According to these doctrines, prevalent up to 1840, and founded by De Saussure and Sprengel, vegetable and animal life depended on the circulation of organic matter, formerly endowed with vitality. When all the remains of dead plants and animals in cultivated land had been set in motion, brought into the circulation, and in this way rendered available, an increase of produce by cultivation, beyond this limit, was no longer possible, nor an increase of the population conceivable. My researches on the processes of putrefaction and decay (which form the second part of my book), and on humus, had in the mean time led me to another and a totally different view, which may be thus expressed:

The increase of organic life is unlimited; all the constituents of the food of plants are inorganic (or mineral) substances.*

"A beautiful connexion subsists between the organic and inorganic

* Of course, the writer means "save by the extent of land on the globe capable of supporting vegetation." We are still very far from this limit.—W. G.

kingdoms of nature. Inorganic matter affords food to plants, and they, on the other hand, yield the means of subsistence to animals. Plants find new nutritive material only in inorganic substances. Hence one great end of vegetable life is to generate matter adapted for the nutrition of animals, out of inorganic substances, which are not fitted for that purpose."—p. 12.

Carbonic acid, ammonia, water, sulphuric acid, nitric acid, phosphoric acid, are inorganic or mineral substances.

In contrast to those inorganic nutritive matters which plants receive from the atmosphere (carbonic acid, water, ammonia, nitric acid), they require for their formation and the development of their vitality, certain inorganic substances, derived from the soil, which we find in their ashes after they have been burned.

These constituents of the ashes of plants are nutritive materials and not stimulants. The atmospheric nutritive materials only act when the plants are at the same time supplied with the materials of nutrition derived from the soil.

When plants require, for their nutrition and development, certain materials of nutrition derived from the soil, which materials were originally constituents of certain minerals, then the nutritive power or the fertility of the soil is proportional to the amount of these materials which it contains; they are the first conditions essential to the cultivation of plants. The nutritive power of the atmosphere is proportional to the amount of gaseous nutritive matters contained in it. These last belong, by their nature and origin, to the same class as the nutritive matters of the soil: but the nutritive materials of the soil are never gaseous; and as we are in the habit of regarding air and earth as opposed to each other, I shall employ, in the following considerations, as is uniformly done in science, carbonic acid and ammonia (which are mineral constituents of the atmosphere), or atmospheric materials of nutrition, and the mineral constituents of the soil, or terrestrial materials of nutrition, as contrasted with one another; which, however, it is self-evident that they are not, if we consider their nature. The carbonic acid in limestone, and the ammonia in sulphate of ammonia, are not gaseous and can never be constituents of the atmosphere in these forms of combination.

The *duration* of the fertility of a field or soil is proportional to the quantity or the sum of those conditions of nutritive power which are present in the soil; that is, of the nutritive constituents of the soil.

The *exhaustion* of the soil by cultivation is directly proportional to that part of this quantity or sum which the soil has annually yielded to the crop raised on it.

Since neither the nutritive constituents of the atmosphere *alone*, nor those of the soil *alone*, exert any influence whatever on the

development of plants, the atmospheric nutritive materials are the indispensable conditions of the conversion of the terrestrial nutritive materials into organic compounds; and the terrestrial nutritive materials are, in like manner, the indispensable conditions of the conversion of the atmospheric nutritive materials into corn and cattle. (See 'Agricultural Chemistry,' pp. 195, 187.)

The amount of produce of a field in a given time, say in a year, is proportional to that part of the sum of the terrestrial nutritive constituents, which, during that year, has been transferred from the soil to the plants growing on it. In a double crop there is double the quantity of terrestrial elements of nutrition.

These propositions are self-evident, and require no further proof.

Experience demonstrates that the produce of two fields in the same district, or the quantities of corn or cattle raised on them, are very unequal. One meadow yields twice, thrice, four times as much hay as another meadow of equal surface, under the same external circumstances. An acre of clover in one field yields twice, thrice, or four times as much clover as an acre of another clover-field. There are fields, nay entire districts, on which clover either does not grow or grows but poorly.

What is the cause of this unequal fertility? The surface of the fertile, and that of the unfruitful field, are in contact with a precisely equal volume of air; to both, therefore, are presented, by the air and by the rain, precisely equal quantities of carbonic acid and ammonia; but on the surface of the so-called fertile field, twice, thrice, or four times as much carbon and nitrogen are condensed as on the equal surface of the other. It is plain that the cause of the difference of produce must be sought for, not in the atmosphere, but in the soil: this cause must be the unequal quality of the soil, while the external conditions are the same.

In the fertile soil, twice, thrice, or four times as much of the terrestrial elements of nutrition have entered into the plants, than in the unfruitful one. There have therefore been more of these terrestrial constituents present, either absolutely or as regards their capacity of assimilation (their power of entering into the plant, from their existing in available chemical forms) in the one soil than in the other.

The amount of produce, in these cases, is unquestionably proportional to the quantity of mineral elements of nutrition present in the soils, and not to the quantity of carbonic acid and ammonia, for the atmosphere has supplied to both an equal quantity of these materials; but in the one soil the conditions of

their conversion into organic compounds were efficient or operative in greater quantity, during the same time, than in the other.

If we now suppose the atmosphere to supply to two fields, as above, of unequal fertility, instead of the ordinary quantity, twice, thrice, or four times as much ammonia and carbonic acid, and in equal proportion to both fields, the produce will still be unequal; that of the fertile field will still be higher than that of the other, and that in the same proportion as before, for the conditions of fertility in these soils are, in both, the same in amount as they formerly were.

If the produce is greater, when the supply of carbonic acid and ammonia is doubled, than with the ordinary supply, this can only depend on the circumstance, that in both fields more of the terrestrial elements of nutrition have become soluble and available in the given time. Experience teaches us that a fertile field, if supplied with more ammonia than the air supplies, yields a heavier produce. Experience teaches farther, that the increase of produce, under these circumstances, in two fields of unequal fertility, is not proportional to the increased supply of ammonia; that the produce of the one, for example, of a clay soil, is doubled or trebled by the simple addition of as much ammonia as was already supplied; while the produce of the other field, of equal size, for example, of a sandy soil, is not increased, or not materially increased, by the addition of twice or thrice as much ammonia as was formerly supplied to it.

Since the efficacy of the carbonic acid and ammonia supplied to the soil always depends on the quality of the soil, it is easy to understand that, even in the altered circumstances above supposed, the amount of produce must always be proportional to the quantity of the mineral elements of nutrition present in the soil, in a soluble or available form. An excess of ammonia cannot supply a deficiency of these mineral elements, nor convert a misproportion among them into a due proportion.

I have, in my book, subjected to examination the effect of an increased supply of carbonic acid and ammonia in the soil, and I have been led to an explanation of this action totally different from that generally adopted.

Nothing appears, at first sight, more simple and obvious than the opinion that the atmospheric elements of nutrition, when artificially supplied to cultivated soils, as in humus and ammonia, increase the produce, because they are available, directly and immediately, as food for plants, and are actually thus taken up; but a closer investigation leads to the conclusion that this explanation, as a general rule, cannot be the true one.

The consideration of agriculture on the great scale shows, that

the quantity of nitrogen which the soil receives in the shape of manure, is but a small fraction of the sum of nitrogen which is reaped in the crops; on the contrary, cultivation on the small scale shows, that the quantity of nitrogen, which is reaped in the crops on a soil richly manured with ammoniacal salts, is but a small fraction of that which has been supplied to the soil. In cultivation on the great scale much more nitrogen, in all experiments with ammoniacal salts on the small scale much less nitrogen, is reaped in the crops than the soil has received in the manure. The considerations on which my explanation is founded are the following:—

If we imagine to ourselves a lake containing an inexhaustible amount of water, from which hundreds of canals convey, each a limited quantity of water to as many mills, it is plain that, even if each mill receives the same amount of water, the effect of this water, which is produced by its fall, may be very unequal. One mill grinds, in 24 hours, 20 sacks of flour; another yields in the same time 30, a third 50, a fourth 100 sacks of flour. These unequal effects, with equal quantities of water, depend, as is well known (the fall being supposed the same in all), on the construction of the mill-wheel. With a badly-constructed wheel, one-half or one-third of the water runs past the buckets without producing any effect. The maximum of effect is produced when every drop of water is allowed to exert its proper effect, when all obstacles are removed, which cause a loss of water or interfere with its action; and this every miller, who understands something of mechanics, can secure by a certain form and construction of the wheel and the buckets.

Precisely similar is the relation of the atmosphere to plants. The air (and, as I have shown by my analyses, the soil) contains an inexhaustible magazine of ammonia and carbonic acid. To each field, that is, to each equal surface, is supplied an equal but limited quantity, sufficient for the most luxuriant vegetation; and the art of the farmer consists essentially in fixing in his fields the whole supply of carbonic acid and ammonia thus offered, or in converting it into a maximum of bread and flesh. This is done in the cultivation of his crops.

The food of plants is taken up by means of their roots and leaves (see the chapter on the origin and action of humus, 'Agricultural Chemistry,' p. 29). "*The size which a plant acquires in a given time is proportional to the surface of the organs destined to convey food to it*" (p. 31). With the surface and number of the leaves and of the root-fibres, the power of the plant to take up ammonia and carbonic acid increases, and in the same degree. A plant with ten leaves and ten root-fibres takes up in the same time only half as much as a plant with twenty leaves and twenty

root-fibres, of the same size (p. 32). When all the conditions indispensable to the conversion of carbonic acid into a constituent of the plant, and which must be derived from the soil, are present in sufficient quantity and in available forms, then only so much carbonic acid can be fixed or condensed as is presented to its organs of absorption by the surrounding media (p. 196). Without a simultaneous supply of ammonia, the plant does not attain its full development (p. 187).

But if to the roots and leaves of the young plant there be supplied, in the same time, three times as much carbonic acid as the air contains, there will be formed, in the same time, four times as many roots, leaves, and buds. The surface, and with it the power of the plants to take up food from the air through the leaves, will be increased fourfold beyond what it would have been without this additional supply (p. 196). The plant will take up more mineral food, in direct proportion to the increase of its mass derived from the soil. The number and size of the seeds will depend on the quantity of mineral elements of nutrition which the soil has yielded to the plant in the same time (p. 197). The effect of the carbonic acid artificially supplied, as well as that of the ammonia (p. 211) consists, therefore, in the *gaining of time* (p. 199).

The increase in the produce of a field depends, on the whole, *in cultivation on the great scale*, according to the preceding explanation, on this: that while we provide in the soil, at the favourable time, a source of carbonic acid and ammonia, the absorbing surface of the field is increased, both upwards and downwards, by these nutritive materials. A double surface of leaves must come in contact with twice as many particles of air, and must take up, in the same time, twice as much carbonic acid. The air, in the same time, is more completely deprived of its carbonic acid.* A double number of root-fibres receives twice as much of the terrestrial elements of nutrition from the soil. By the mechanical preparation of the soil we remove the obstacles which impede the

* Mr. Lawes, obviously under the impression, as it appears to me, that my explanation is quite new, and not aware that it is to be found, verbatim, in my book, since 1843, has made the following remarks on it (Journal, vol. xvi. p. 453). "What, we would ask again, is *gain of time*, in the growth of plants, but the very essence of the distinction between natural growth and artificial growth, that is, agriculture? In this admission is involved the fullest and most convincing proof that, if any of the constituents of plants should have attributed to them a *preponderating* value and importance, it should be those to which is due a gain of time."

I can only rejoice that Mr. Lawes has now recognized the significance of my explanation. When, five years ago, Dr. Daubeny directed his, Mr. Lawes', attention to it, he clearly did not understand it (Journal, i. 40); but my little pamphlet ('Principles of Agricultural Chemistry') appears to have opened his eyes. It is self-evident that science knows nothing of a preponderating value of any one element of nutrition. Each of them has, under certain circumstances, a value or importance beyond the others.

simultaneous action of these terrestrial elements; for if they are not present, during the same time, in due quantity and of due, that is, available quality, and if they are not taken up by the plants, the most abundant supply of carbonic acid and of ammonia can produce no effect. ('Agricultural Chemistry,' p. 187.)

The draining of the soil promotes vegetation, because it gives to the atmospheric elements of nutrition free access to the roots of the plants, and it augments the produce, because vegetation is thus accelerated, and time is gained for the absorption of nutritive matters.

In agriculture, no factor, or element of the calculation, is more important than that of *time;* and the too great neglect of this consideration in farming is unquestionably the most serious obstacle to its progress. *The just appreciation of the value of any special manure depends on a knowledge of its effects in time.* An individual manure, which, in one year, may increase the produce of a field in the most astonishing manner, may, if applied to the same field in the same way for five years, produce not the slightest effect, or even a diminution of the produce. Hence arises, when the manure is used for a short time, an over-estimate of its value, and in a longer period, an unmerited depreciation of it. Two farmers, who are to day of precisely the same mind as to the value of a special manure, come, after a few years, to opinions diametrically opposed on the same subject, because the same manure, applied to different kinds of soil, exerts very unequal influences, if we look to the duration, that is, the time, of its effects.

An additional source of carbonic acid and ammonia accelerates the action of the terrestrial elements of nutrition in the same time; the increased produce means nothing else.

If the produce of a field, without the addition of ammonia, be = 1000, then a certain amount or sum of terrestrial or mineral elements has been transferred from the soil to the plants in this crop = 1000.

If, by the use of ammonia, the produce has risen in the same time, a year, to be = 2000, then, twice as much of the mineral elements has been removed from the soil in the same time.

It follows from this, that if a soil contain so much of these mineral elements that it can yield, in 100 years, without anything being restored to the soil, exactly 100 crops of wheat, it will cease, after that period (100 years), to be fertile for wheat.

If, now, by the addition of carbonic acid and ammonia, or of ammonia alone, the produce of this soil, in one year, be doubled, then the soil thus treated will supply, in 50 years, as much produce as it would have done, without ammonia, in 100 years. The soil will have lost, in 50 years, as much of the mineral ele-

ments of nutrition as it would have lost, without ammonia, in 100 years.

By this application of ammonia, the field will not have produced more wheat, on the whole, than it would have produced without ammonia, but only more *in the same time.*

We can now understand, *that the total produce of our fields, or their fertility, must be proportional to the sum of the mineral elements of nutrition contained in the soil, and that the amount or weight of the produce in a given time is proportional to the rapidity of the action of these mineral elements in that time.*

The experiments hitherto made in farming, in reference to this point, have never been made with ammonia *alone*, or with nitric acid *alone*, but always with ammoniacal *salts*, and *nitrates*, that is, *salts* of nitric acid.

Now it is evident that if the acids which accompany ammonia in the ammoniacal salts, and the bases which accompany nitric acid in the nitrates, take a certain share in vegetation, they must in that case act precisely as if the sum of terrestrial elements had been increased, or their action accelerated, that is, increased in a given time. The effect of the ammonia or nitric acid must be essentially modified by the presence of the accompanying substances, according to the deficiency or excess of these in the soil. If an excess of sulphuric acid be present in the soil, then ammonia, accompanied by sulphuric acid, will exert a less influence, or yield a less produce, than muriate of ammonia would do if there were a deficiency of muriatic acid in the soil.

The crops on fields manured with ammoniacal salts or nitrates can therefore never be proportional to the supply of nitrogen in the manure, but must rise and fall according to the nature and action of the substances supplied along with it. The most beautiful and convincing experiments, in regard to these essential questions, were made in the years 1843-46, by F. Kuhlmann of Lille, and Schattenmann ('Comptes Rendus,' vol. xvii. p. 1121; 'Ann. de Ch. et de Ph.,' vol. xviii. p. 143; *ib.* p. 279). These experiments are hardly known in agricultural circles, and I therefore give them here in detail. They have contributed not a little to render immoveable my conviction of the truth of the doctrines I hold.

By manuring a meadow with ammonia and nitrates, Kuhlmann obtained an increase in the produce of hay, in 1843, which, calculated for 100 parts of nitrogen, was as follows, for equal surfaces:—

Nitrogen in the Manure.	Produced increase in Crop.
100 parts in the form of sal ammoniac	2439 parts of hay.
" " sulphate of ammonia ..	2160 "
" " nitrate of soda	4005 "

Thus 100 parts of nitrogen, as nitrate of soda, yielded upwards of 90 per cent. more increase in the produce of hay than the same quantity of nitrogen, as sulphate of ammonia.

Again, an equal surface of meadow, manured for three successive years, first with sulphate of ammonia, then with nitrate of lime, and lastly with nitrate of soda, yielded, for 100 parts of nitrogen in the manure, the following increase of produce :—

Nitrogen in Manure.	Yielded increase of Produce.
100 parts in the form of sulphate of ammonia ..	3140 parts of hay.
„ „ nitrate of lime	2593 „
„ „ nitrate of soda	4870 „

The same quantity of nitric acid, which, united to lime, had yielded 2593 lbs. of hay increase, yielded, when united to soda, 4870 lbs. of hay, that is, upwards of 90 per cent. more.

These results prove irrefragably that the crops on a field, manured with ammoniacal salts or nitrates, is not proportional to the supply of nitrogen in the manure; for the same weights of nitrogen in the same field give, not equal, but most unequal crops.

It follows farther, from these experiments, that if to the ammoniacal salts we add other substances, which by themselves are capable of taking a part in vegetation, that is, which can serve as food to plants: that, in this case, the proportion of the crop to the nitrogen supplied in the manure must again be changed; because, to the action of the nitrogen in ammonia by itself, and to that of the substance accompanying it in the salt, is added that of a new factor.

By manuring a meadow with 666 parts by weight of sal ammoniac and phosphate of lime, Kuhlmann obtained, in 1844, 1845, and 1846, an excess of produce over that of an equal surface of unmanured land equal to 7686 parts, by weight, of hay.

An equal surface, manured with 300 parts, by weight, of guano, containing 5 per cent. of nitrogen, yielded, in the same years, an increase of produce equal to 2469 parts, by weight, of hay. From these results it appears that—

Nitrogen in Manure.	Yielded increase of Produce.
100 parts in the form of sal ammoniac	2,439 parts of hay.
„ „ sal ammoniac with phosphate of lime	4,367 „
„ „ guano	16,460 „

In 1846, in Kuhlman's experiments, 200 parts, by weight, of sulphate of ammonia yielded an increase equal to 2533 parts of hay; and an equal surface, which received 200 parts of sulphate of ammonia, with the addition of 133 parts of common salt, yielded an increase equal to 3173 parts of hay. The significance of these results is obvious and easily understood.

When the ammoniacal salts used as manure are accompanied by mineral substances which are also elements of nutrition for plants, the produce is proportional, not to the nitrogen in the manure, but to the effect of these mineral substances.

By the use of the phosphate of lime, the effect of the ammonia in sal ammoniac was almost doubled. By the action of the substances which in guano accompany the ammonia, the effect of the latter was made seven times greater than that of the same quantity in the shape of sal ammoniac alone. By the addition of common salt to the sulphate of ammonia, the effect of the ammonia in that salt was increased 25 per cent.

Since the effect of a manure is not proportional to the quantity of nitrogen it contains, it will be easily understood why the value of a manure cannot be estimated by its percentage of nitrogen.

According to the best analyses, it may be assumed that meadow hay contains 1 per cent. of nitrogen; consequently, in 100 parts of nitrogen are contained 10,000 parts of hay. If we compare with this quantity of hay the increased produce of hay produced by 100 parts of nitrogen in Kuhlmann's experiments with ammoniacal salts, it appears that in this increase we only receive from one-fifth to one-fourth of the quantity of nitrogen supplied in the manure, and therefore that an apparent loss of four-fifths, or three-fourths, of this nitrogen has taken place.

In reality, no loss has occurred. That which might be regarded as loss is the portion of ammonia which has not acted; and this portion has not acted, because ammonia, by itself, produces no effect; and only then does or can act, when the other conditions are present which enable it to take a share in vegetation.

It might be supposed that the portion of ammonia which has not been assimilated, from want of the necessary conditions, has yet been taken up by the roots, and has evaporated through the stem and leaves, and that consequently no ammoniacal salt is left in the soil after the harvest. This idea is very unlikely to be true, for it presupposes that the whole residue of ammonia, and indeed every atom of it, has come into contact with the absorbent root-fibres and been absorbed. This is impossible, for the ammoniacal salts are conveyed to every part of the soil; but there are not root-fibres in every part of the soil to absorb it, unless we suppose the root-fibres to exert on the particles of ammonia scattered in the soil the same influence which a powerful magnet exerts on the particles of iron filings, diffused through a heap of sand. But we know that the root-fibres can only absorb those particles which are in immediate contact with them, and that they exert no attractive power even at the shortest distance. Observation supplies no fact to prove, either that ammonia

actually evaporates through the leaves of plants, or that sulphate of ammonia, or sal-ammoniac, can evaporate at all under these circumstances.

The most direct proof against this assumption (which in scientific language is called a mere hypothesis, since it is destitute of all foundation in fact) is the circumstance, that, when guano was applied in Kuhlmann's experiments, not only was no loss of nitrogen sustained, but in the hay obtained there was contained 64 per cent. of nitrogen beyond what was added to the soil in the guano. This excess of 64 per cent. of nitrogen in the crop was spread over the three years of the experiment as follows:—

For 100 parts of nitrogen in the guano there was obtained in the hay,—

In 1844	105½	parts of nitrogen.
1845	22½	"
1846	36	"
Total nitrogen in the crops, including 100	——	
parts from the guano	164	parts.

Consequently, in this experiment, not only no evaporation of active or available nitrogen took place, but precisely the reverse of loss occurred; for an absorption and assimilation of nitrogen from the natural sources, in addition to that in the guano, was observed.

The opinion or hypothesis that the nitrogen added to the soil in excess, in manuring with nitrogenised manure, for example, with ammoniacal salts, is taken up by the plants, loses its nutritive power, and evaporates through the stem and leaves, and that the soil, by the cultivation of the gramineæ, suffers a loss of nitrogen, is shown by the preceding considerations to have no scientific foundation whatever. The fact is, that when a field has been manured with ammoniacal salts in one year, and has yielded in that year an increased produce, it yields, in the next year, if sown with the same plant, a less abundant crop than an equal surface of the same land in the second year, which has received no ammoniacal salts in the preceding one. This deficiency is a result of experiment; but the conclusion drawn from it, that it is caused by a loss of nitrogen, is not a true or logical conclusion, but a mere fancy, an hypothesis. The deficiency is explained by the following considerations.

The effect of ammoniacal salts is not the same as that of free ammonia. These salts contain an acid which exerts an action on the constituents of the soil, an action not exerted by pure ammonia. The acids of the ammoniacal salts render the earthy phosphates more soluble in water than they would otherwise be. These acids also render available the silicates; that is, they produce such a decomposition of the natural silicates, that the con-

stituents of these minerals acquire a degree of solubility in solvents, which, while in the form of natural silicates, they either do not possess, or possess in a far lower degree. While the silicates are thus acted on, their silica or silicic acid (which is indispensably necessary to the gramineæ) is brought into a state in which it is soluble in water, so that all the rain-water which comes in contact with it finds and dissolves a certain quantity of silicic acid beyond that quantity which the same amount of rain-water would have found available without the ammoniacal salts.* By means of the atmospheric constituents accumulated in the soil, by means, for example, of ammonia, the action of the mineral constituents which are present in available or soluble forms is accelerated, that is, increased *in a given time.*

By means of ammoniacal salts a part of the insoluble mineral constituents present in the soil is rendered soluble, and a larger fraction of the entire sum of mineral constituents is rendered active, or capable of entering into the plant; consequently, by manuring with ammoniacal salts, there is removed from the soil, in the excess of produce reaped in the first year, a part of those mineral constituents which would have been rendered soluble and available by natural causes in the second year. The soil, *in the second year*, is *poorer* in these available mineral constituents than it would have been had no ammoniacal salts been applied in the preceding year.

Of two fields, of which one has been manured with ammoniacal salts, and the other left unmanured, the former will give in the first year a larger produce ; but if the same two fields be left unmanured the second year, the proportions of produce will be reversed. The field not manured in the first year must yield in the second a decidedly higher produce than the other, because the higher produce of the manured field in the first year must have caused a greater consumption of mineral constituents, and this must have produced a corresponding exhaustion of these constituents ; consequently, a copious supply of ammoniacal salts alone (if the mineral constituents removed in the excess of produce caused by this manure in the first year are not replaced) cannot naturally exert any influence in the augmentation of the produce of a field in the succeeding years, because the action of these salts is in part a chemical one.

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* Hydrated silicic acid is more soluble in pure water than in water containing ammoniacal salts ; since, according to the experiments of Way, and my own, ammoniacal salts are removed from water by the soil, and lose their solubility, they do not present any obstacle to the absorption of silica by the roots ; and lastly, since on 1 acre of land more than a million of pounds of rain-water falls, the proportion of ammoniacal salts which can remain dissolved, where an excess of them has been applied, is too trifling to form any material obstacle to the absorption of silica.

A body which has excited a chemical action loses thereby the power of exerting this action a second time. When sulphuric or muriatic acid exerts a chemical action, or decomposition, it enters into a chemical combination, in which the acid has entirely lost its properties. Hence we can easily see why ammoniacal salts, in spite of the excess of ammonia which remains in the soil in the second year, have apparently an effect so little durable. This is because the excess of ammonia can exert no nutritive action when the conditions of its efficacy, namely, the mineral constituents, are wanting; when they have been consumed in producing the excess of produce in the previous year.

The experiments of Kuhlmann, as well as those of Lawes, supply the most convincing proofs of the truth of these deductions. The fields which Kuhlmann had manured, in 1844, with ammoniacal salts and nitrates, yielded, in 1845, when unmanured, a less produce than was obtained from an equal surface which had not received any manure in 1844. That one which, in 1844, received 500 lbs. of sulphate of ammonia, yielded in 1845, unmanured, 8340 lbs. of hay. That which was not manured in 1844 yielded, without manure, in 1845, 8972 lbs. of hay; that is, 632 lbs. more than the other. Still more striking is the following fact. Kuhlmann had manured a portion of his field in 1844 with a mixture of 666 lbs. of sal-ammoniac, along with phosphate of lime, and had obtained an excess of produce = 12,172 lbs. of hay per hectare. In the same year the portion manured with 500 lbs. of sulphate of ammonia (without phosphate of lime) yielded an excess = 3488 lbs. of hay. The former, therefore, yielded 2½ times more excess of produce than the latter.

Meadow-plants, like all others, require for their development phosphate of lime and ammonia, but also, besides these, other elements of nutrition; for example, silica and alkalies, without which they cannot thrive. By the addition of phosphate of lime to the ammoniacal salt the effect of the latter was augmented: there were obtained in all 8684 lbs. of hay more than by the use of the ammoniacal salts alone. Now, in this excess, which is equal to 2½ times the whole excess obtained by the ammoniacal salts alone, there were contained 2½ times more silica, and 2½ times more potash than would have been removed from the soil without the use of phosphate of lime along with the ammoniacal salts; and the soil was rendered necessarily by so much the poorer in these constituents. This great loss of indispensable constituents could not be without influence on the subsequent crops. The field which in 1844 had been manured with 500 lbs. of sulphate of ammonia had no manure in 1845, and received, in 1846, 500 lbs. of the same ammoniacal salt. The result was as follows:—The same quantity of phosphate of lime and sal-ammoniac, which in

1844 had yielded a produce higher by 8684 lbs. than that of the field manured with sulphate of ammonia alone, yielded, in 1846, 3592 lbs. of hay. *The field manured with sulphate of ammonia alone yielded, in* 1846, 3726 *lbs. of hay; that is,* 124 *lbs. more than the other.* The same manures which in 1844 had produced an enormous increase, and to which the unscientific and ignorant farmer would certainly, on account of this result, have attributed a preponderating value, lost, in 1846, their effect, although applied in the same quantity, and in the same proportions, to the same soil; and they lost their effect in the subsequent years, in the same degree as they had at first produced a favourable result. The increased produce of the first year determined the diminished produce in the second and third years.*

We see from these facts that the effect of each individual manure, or the produce obtained by it, is dependant on fixed and immutable natural laws, which must not be disobeyed nor neglected, if the farmer wishes to secure the continuance or duration of his crops. By the use of ammoniacal salts *alone* we can increase the produce of a field in a given time, but not on the whole. The quantity of corn and cattle which a given surface can yield stands in a fixed relation of dependance, *which can only be modified in regard to the time over which the action extends,* to the sum of the mineral constituents which the soil contains, and which it can yield to the plant.

If Kuhlmann had continued his experiments for ten or fifteen years, it is as certain as any mathematical truth is, that with all his expenditure of manure (ammoniacal salts) he would not have obtained in that time 1 cwt. of hay more than his meadow would have yielded without any manure whatever. The effect of any special manure, for one year, does not enable us to draw any conclusion as to its effect in a second year; and if such a manure should produce a favourable result during five successive years, it is certain that it will not have the same effect during ten years.

No one can rationally suppose that there exist, for the legumi-

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* "Thus we have shown, that after supplying to the soil twice or thrice as much nitrogen as was obtained in the increase yielded, there was, in the succeeding year, no increase whatever due to the nitrogen not recovered in the year of the application; or that such increase, if any, was not only extremely small, but that it occurred only when the application of the previous year had been obviously very excessive."—*Journal*, vol. xvi. p. 475.

"The instances given in Table V. *prove the fact* that a moderate supply of ammoniacal salts to the wheat-crop did not leave any efficient residue for the succeeding season."—*Ib.* p. 478.

According to Mr. Lawes, a moderate supply is from 224 lbs. to 336 lbs. of ammoniacal salts. This is from three to five times as much as is required for the increase in a crop of wheat, calculated on its percentage of nitrogen. In scientific language, Mr. Lawes, instead of saying that the instances *prove the fact*, ought to have said, "The instances given in Table V. show that there was, in the succeeding year, no increase whatever."

nosæ and gramineæ of our cultivated fields, laws of nutrition different from those which apply to the plants of the same orders which constitute the chief mass of our meadow crops, nor that nature has created special laws, by way of exception, for the wheat plant.

In this point of view the experiments made by Schattermann in 1843 are peculiarly instructive, and well calculated to remove every doubt. (See 'Comptes Rendus,' vol. xvii. p. 1128, 1843.)

Schattermann manured ten equal plots of a large wheat-field with sal ammoniac and sulphate of ammonia, and left unmanured a plot of equal size. Of the manured plots one received 162 kilogrammes, or 340 lbs. per acre English; others twice, thrice, and four times that quantity of each of these salts.

"The ammoniacal salts," says Schattermann (p. 1130), "appear to exert an extraordinary influence on wheat; for only eight days after the manuring the plants acquired a deep green colour, a sure sign of great vegetative energy."

The produce obtained by this manuring with ammoniacal salts was as follows:—

Quantity of Ammonical Salt.	Produce in Kilogrammes.*			
	Grain.	Straw.	Grain less.	Straw more.
1 acre—none	1182	2867	..	..
1 acre—162 kil. sal ammoniac	1138	3217	44	348
4 acres—1st, 324 k.; 2nd, 324 k.; 3rd, 486 k.; 4th, 486 k., of sal ammoniac: average produced	878	3171	304	314
1 acre—162 kil. sulphate of ammonia	1174	3073	8	211
4 acres—1st, 324 k.; 2nd, 324 k.; 3rd, 486 k.; 4th, 648 k., of sulphate of ammonia; average ..	903	3248	279	381

These results, obtained by manuring a wheat-field with ammoniacal salts, tell us more than a whole volume full of figures.

In all these impartial and trustworthy experiments the produce of *grain* was diminished by the use of ammoniacal salts. The deficiency was less, on the plot manured with the smallest quantity of these salts, than on those which had received an excess.

The produce of straw alone was increased. For 1 lb. of ammoniacal salt there was obtained, on an average, about 1 lb. of increase in the produce of straw.

Any one inexperienced in the treatment of scientific questions would think himself justified in drawing, from these experiments,

* The kilogramme is equal to 2·1 lbs. avoirdupois.

the conclusion, *that nitrogenised manures are altogether unfit for grain*, because, by their use, the produce of grain was diminished, and because the deficiency increased with the amount of the ammoniacal salts employed as manure.

Yet this conclusion, which is, in this form, a direct contradiction to those of Mr. Lawes, is no better founded than those latter conclusions, according to which *nitrogenised manures are peculiarly appropriate for grain*, because the increase or diminution of the produce is proportional to the presence or the deficiency in the soil of those mineral constituents which the soil must supply to grain for its development simultaneously with the ammonia. If these mineral constituents are deficient or absent, while others, required for the straw, are rendered soluble and available in greater proportion by the action of the ammoniacal salts, then the produce of grain diminishes, while that of straw increases; in spite of the excess of ammonia no more nitrogen is assimilated than is supplied by the natural sources of that element.

A single indispensable mineral constituent, no matter which, determines and regulates the produce. If all the others be present in excess, while this one is deficient, the plant does not thrive. If this one constituent be present, in an available form, and exactly in the proportion required for the growth of a full crop of wheat, and if the soil receives no ammonia artificially, the plant obtains its supply of nitrogen from natural sources; an excess of ammonia is not assimilated. If *all* the mineral constituents are present on the soil and in excess, then, by the addition of ammoniacal salts, the produce is increased, for in that case the conditions of the assimilation of the ammonia are secured.*

From these very facts it follows, indisputably, that if the farmer wishes to preserve the fertility of his fields, or if he wishes to increase their produce, he must, before all other considerations, attend to the importance of rendering available and efficient the constituents present in the soil. He must enrich the soil with mineral constituents supplied from without, and supply such as are wanting, if he would increase his produce in a given time; and if he would render durable the increased produce, he must restore to the soil all the mineral constituents removed in his crops, and in the same proportions. The whole art of agriculture must be directed to these objects, and when the farmer has, in this way, given to his soil the necessary quality, then the use of nitrogenised manures will give the most satisfactory results.

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* Schattermann observes, that with lucerne and clover, ammoniacal salts had no perceptible effect.

In 1843 I formulated in the following manner these natural laws of the manuring of soils. ('Agr. Chem.,' see Appendix, where they are printed in full connexion, pp. 211 to 214.)

"We cannot augment the fertility of our fields, or their power of production, by supplying them with manure rich in nitrogen, or with ammoniacal salts alone. The crops of a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in the manure."—p. 211.*

For the illustration of this sentence, and that the meaning conveyed by it might not be doubtful, I added the following sentences, in reading which, it must be borne in mind, that I had in view three kinds of manure, *ammoniacal salts alone*, *ammoniacal salts with mineral constituents*, and *mineral constituents alone*.

In these sentences I said—

1. "If the mineral constituents are wanting in the manure, and if we give ammonia alone, no nitrogen is assimilated, and no crop is obtained."—p. 211.
2. "The ammonia in animal excreta only exerts so favourable an influence, because it is accompanied by mineral constituents."—p. 212.
3. "It follows from this, that ammonia is assimilated when it is accompanied by these mineral constituents."
4. "When ammonia is wanting in the manure—that is, when it contains only the mineral constituents—the nitrogen is obtained from the atmosphere."

In order to remove any doubt as to the meaning of this proposition, the following one is subjoined in my book:—

"Ammonia accelerates and favours the growth of plants on all kinds of soil, in which exist the conditions for its assimilation; but it is quite without action where these conditions do not exist."

Fearing that these propositions might nevertheless be misunderstood, and that the false doctrine might be ascribed to me, that the produce of the soil was dependant solely on the supply of mineral constituents, the following sentence was added in the English edition (p. 213):—

"In order to obviate any misunderstanding, we must again draw attention to the fact that this explanation is not in any way contradicted by the effect produced by the application of artificial ammonia or its salts. Ammonia was, and is still, considered as the source of all the nitrogen of plants; its supply is never injurious; on the contrary, it is always useful, and, for certain purposes, indispensable. But, at the same time, it is of great importance for agriculture to know, that the supply of ammonia is unnecessary for most of our cultivated plants, and that it may be even superfluous, if only the soil contain a sufficient supply of the mineral food of plants, when the ammonia

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* In the German edition, of which the English is a translation, this sentence stands thus: "instead of "the crops of a field" it is "the power of production of a field" (in German, "seine Produktionsvermögen).—Author.

This error is here of little moment, because in the preceding sentence, as above quoted, the terms "fertility" and "power of production," both accurately representing the German, are used.—Translator.

required for their development will be furnished by the atmosphere."—p. 213.*

Keeping in mind what I have said in the chapter on manure (pp. 188, 189, 190, 191, 192), concerning the action of the ammonia therein contained, no reader of sound judgment could, I should have supposed, have misunderstood my meaning.

The reader knows what Mr. Lawes has made of these simple and intelligible propositions. In his conclusion (Journal, vol. xii. p. 39), leaving out the word manure, he misrepresents me as having said, that

"We cannot increase the fertility of our fields by a supply of nitrogenous products or by salts of ammonia alone, but rather that their produce increases or diminishes in a direct ratio with the supply of mineral elements capable of assimilation."

In his paper ('On some Points,' vol. xvi. p. 464) he omits the first part of the sentence above quoted, and imputes to me the following general proposition:—

"Thus, speaking of the supply of ammonia, he (Liebig) says that it may be even superfluous, *if only the soil contain a sufficient supply of the mineral food of plants*, when the ammonia supplied. by their development will be supplied by the atmosphere."

In the first part of the sentence, to which the word "superfluous" refers, I had specified "most of our cultivated crops."

By these means Mr. Lawes endeavours to make the world believe that I have taught:—

1. That the effect of manure is proportional to the mineral constituents which it contains *alone*.
2. That it is superfluous to supply ammonia in the manure to any cultivated plant whatever.†

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* The translation here is perhaps not verbally quite exact. Instead of "artificial ammonia" the original has "artificial application of ammonia;" and instead of "unnecessary for most of our cultivated plants, and that it may be even superfluous," the German has "dass die Zuführ für die meisten Culturpflanze unnöthig und überflüssig sey," which in English means "that the supply (of it) is unnecessary and superfluous for most of our cultivated plants." The word "superfluous" here refers more directly to "most of our cultivated plants" than in the printed translation.

† It would certainly be very unreasonable to make me responsible for the erroneous views which others may have formed of my doctrines. That I have never, at any time, held other opinions, than those which I have defended in the preceding pages and in my 'Principles of Agricultural Chemistry,' is surely demonstrated most convincingly in those publications of mine which appeared simultaneously with the third and fourth editions of my 'Agricultural Chemistry.' In my 'Handbuch der Organischen Chemie,' we find, at p. 1398 (published 1843), the following passage:—

"From the knowledge of the food required by plants are derived several rules highly important in agriculture:—

"1. By the addition to the soil of decaying vegetables the growth of plants is accelerated; the produce of carbon is augmented, inasmuch as we thereby supply a source of carbonic acid.

"2. By

But Mr. Lawes goes still farther. He wishes to make the world believe, that the good effects of ammonia in the manure were unknown *to me*—to me, who, so to speak, first discovered ammonia as an agent in agriculture—who have studied most minutely its action in manures, and, of course, knew this action —while my book is full of it, and I have there given a scientific explanation of its effects. But he goes even much farther than this; for he tries to make it appear that I have recommended, specially, to supply no ammonia to grain crops in the manure; whereas the only passage in my book, in which I have accidentally spoken of the manuring of any special class of plants, and of the advantage of supplying ammonia in the manure, has reference to grain crops:—

"If we furnish to the soil, which contains already all the other constituents, *ammonia*, and to the cereals the phosphates essential to their growth, in the event of their being deficient, we furnish all the conditions for a rich crop." * —See p. 134.

"2. By the addition of sulphurised and nitrogenised substances, we create in the soil a source of ammonia, which contributes to the acceleration of the development of the plants and to the increase of their mass.

"3. Since the conversion of carbonic acid into a constituent of plants is effected by the agency of the alkalies and alkaline earths; since, moreover, without a supply of phosphates no seeds are formed; it is evident that, when carbonic acid and ammonia are supplied, the growth of plants is not accelerated or promoted, unless the mineral constitutents essential to the assimilation of these substances are simultaneously provided."

Again, in my 'Dictionary of Chemistry,' Vol. II. p. 633, are the following words (the first number of this volume appeared in 1842, the last in 1848; the article 'Manure,' from which the following extract is made, appeared in October, 1847, and was written by Dr. W. Hoffman, formerly my assistant in Giessen):—

"Let us suppose a field, which contains in great abundance all the mineral constituents which the plant requires, but in which—that is, in the soil—carbon and nitrogen are entirely absent. If we sow grain in this field, and if air, water, and the proper temperature be supplied, it will yield a full crop, but we shall not obtain the maximum of possible produce. *The problem of cultivation is this: to raise to the highest pitch the produce of the soil.* On account of the short time to which the life of our cultivated plants is limited, we can only attain the maximum of their development by giving to them an additional supply of carbonic acid and ammonia, in the soil, besides that which they can obtain from the atmosphere. By means of the roots left in the ground, and by means of the various secretions of the preceding generation of plants, our cultivated fields are always supplied with a sufficient quantity of carbonaceous matters (humus), which, by their decay, provide an abundant atmosphere of carbonic acid. It is therefore enough, if we add, to the nitrogen which is supplied to plants in the ammonia of the atmosphere, nitrogen derived from animal excreta. From these considerations it evidently appears how high is the value to agriculture of animal excreta, since, if properly treated, they supply to our fields all the elements which are required, not only for the natural development of plants, but also for an artificial increase of that development.

"These are" (says the author of this paper, in the Dictionary which bears my name), "in all essential points, the opinions which Liebig has expressed on this subject in different parts of his work on Chemistry, in its applications to Agriculture and Physiology. Edition, 1846."

* Mr. Lawes says (p. 447), "The efficacy of ammoniacal salts, in yielding an increase of produce, not only in our own experiments, but as a firmly-established

For my part I have, personally, not the slightest interest in the questions connected with the controversy with Mr. Lawes. With chemists and men of science, to whose judgment alone I attach any value, I have nothing to gain if my views prevail; and I have nothing to lose if the views of Mr. Lawes should be adopted by agriculturists. For among men of science and chemists the opinions which I defend are recognised as representing natural laws, and such men are quite indifferent to the result of a discussion which does not affect the subjects of their researches, and has, therefore, no interest for them.

If I enter the lists in defence of the truth of those natural laws, which some have done me the unmerited honour to call my theory, it is solely for the sake of a great cause.

The question is not, here, whether aldehyde be or be not the hydrated oxide of an organic oxide; whether mellone contain 12 or 13 equivalents of nitrogen in one atom; but it concerns matters far more important, and which deeply affect the happiness, the prosperity, and the material progress of the nations.

The true theory of agriculture, founded on natural laws, must enable the agriculturist, who keeps it constantly and steadily in view, to produce on his fields a larger quantity of corn and cattle, permanently and without exhausting the soil, and this by the most economical means.

A false theory cannot enable the agriculturist to attain this object, because it leads him into devious paths, and consequently diverts his attention from that which is truly essential.

I feel deeply indebted to the Editors for the opportunity given me of expressing my opinions on these questions, which I was not able hitherto to do in this Journal. I have treated my theories in chemical science like children, whom we send into the world, and let them try their chance in the school of life, without taking any farther trouble about them. The French chemists inflicted mortal wounds, as they thought, on my theory of Organic Radicals, and banished it without mercy, but I never raised a finger in its defence. The same fate attended my theories of the elements of food, of the formation of fat, of putrefaction, fermentation, and decay; of the formation of prussiate of potash, of the respiratory process; yet I never thought of saying a single word in their defence, because I acknowledge the right of every one to have his own opinions concerning such natural phenomena. If these theories were

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fact, *is now then fully admitted.* And as it was impossible, not only in the face of our own particular experiments, but of now generally recorded experience, *to avoid their admission* in some form, how is it that Baron Liebig brings this result into consistency with the theory which supposes the increase to be proportional to the soluble *minerals* present in the soil?"

fallacious or erroneous, it was not worth while to support them; and if there were truth in them, they would maintain their place; of that I was thoroughly assured. They are now recognised in science in their fundamental points, after it had been believed that many of them had been exterminated, even to their very names, and buried in oblivion; and all this without my having ever entered into a controversy about them.

When I last year, for the first time during ten years, took up the controversy with Mr. Lawes, which I did not begin, it will be, I trust, believed, that it was not for the sake of the vain advantage of proving myself to be right, but because I saw that the most important interests of mankind and of the state were concerned in the question; because the problem must be solved, which is the best way of supplying the wants of our constantly-growing population; because the income and property of the most important section of the inhabitants of the country, namely, of the landed proprietors, must be improved by the application of the true principles of cultivation, and must be endangered by the prevalence of false principles.

Millions of men have believed, during centuries, and many still believe, that the sun revolves round the earth, because to the eye it seems to do so. In like manner, thousands of farmers have believed, and thousands still believe, because to the outward eye it seems so, that all the interests of practical agriculture revolve round "*nitrogen*." Yet this opinion has never been scientifically established; nor can it ever be scientifically established, because all progress and all improvement in agriculture revolve round "*the soil*."

This is the essential distinction between my doctrine and the earlier one, which Mr. Lawes and his followers have revived, and now support. With reference to practical agriculture, the judgment to be formed of the advantage of the use of ammonia and ammoniacal salts, and of the nitrates, rests on the two following considerations:—

The farmer, who cultivates land which is not permanently his property, has the greatest interest in obtaining from the land, during his occupancy, the highest possible produce. The condition in which he leaves the land to his successor is no object of his care. *For this farmer ammoniacal salts and manures very rich in nitrogen, which he supplies from without, are the best and most profitable manures.*

On the other hand, the proprietor of the land has the greatest interest that his land should continue in the same state of fertility in which he has handed it over to the farmer.

The use of manure rich in nitrogen by the farmer prepares for the proprietor the ruin of his land. The greater the quantity of

active mineral constituents extracted from the soil in the crops by the use of such manures, and the less the quantity of these mineral constituents restored to the soil in these manures, the more rapidly does the capital of the proprietor diminish in value by this system of exhaustion.

As in the case of working men and horses, the exhaustion is directly proportional to the work performed. By rightly selected food the power is restored, in men as in horses, of performing on the second day the same amount of work as on the day preceding. Every misproportion in the constituents of the food causes a misproportion in the force produced, and, if continued, ultimately gives rise to a morbid condition.

The manure we place on the land has the same relation to the plants which are to grow on it as the flesh and bread have to the man, the hay and oats to the horse. By rightly selecting the food of plants we enable the land, in the second year, to yield the same produce as in the preceding one. A misproportion among the elements of the manure changes and disturbs, in a shorter or longer time, the fertility of the land.

It is because farmers did not know this natural law, or because they do not keep it in view in its entire strictness, that they have made, and still make, countless experiments to no purpose. To-day, nitrogen and phosphorus constitute the panacea, the universal medicine, with which they propose to cure the land which has become diseased!

I am of opinion that we may make *a free and unlimited use of guano and ammoniacal salts*, if we take the precaution *of adding simultaneously with the guano a certain quantity of the ashes of hard wood, and with the sulphate of ammonia a certain quantity of phosphate of lime and of hard-wood ashes.* In practice, however, *this cannot be accomplished. The more use the farmer makes of special artificial manures, the less farm-yard manure will he use; and the more imperatively will the necessity make itself felt, of replacing the deficient constituents by a supply from without, or, what amounts to the same thing, of making artificial manures more and more analogous in composition to farmyard manure.*

It would be a great error to attempt to make farmers believe that all the land of an extensive country is deficient in nitrogen and phosphorus only, and has an excess of all the other constituents indispensable to cultivated crops. It is a fact, that not thousands, but hundreds of thousands of fields have the same quality as those of Schattermann, the produce of which, when manured with ammoniacal salts alone, diminishes instead of increasing.

The greater the amount of produce derived from land by the use of artificial manures, such as do not restore to the soil all the

necessary constituents, the more and the oftener will the farmer make use of them; and the production of farm-yard manure, by which the misproportions caused by the other manures alluded to in the quality of the soil are in part corrected, must diminish in the same proportion. Many farmers will believe, but only for a time, that they may dispense entirely with it under these circumstances.

I entertain the hope, that perhaps among a thousand one or two may be found who may be induced, by the simple reflection that it can do his land no harm, to follow my advice; and I am certain, in that case, that they will acknowledge in a few years the value of this advice. Their heavy crops will perhaps not be rendered heavier by the restoration of all the mineral constituents, but they will at all events be rendered *permanent*. We shall never have a rational agriculture until, by such experiments, the law of the fertility of the soil, in reference to time, has been brought home to the minds of agriculturists.

The final result of my researches on the nutrition of plants was, that organic manure acted by its constituents, and that it must therefore admit of being replaced by these constituents (p. 177).

A real progress in agriculture appeared to me to be only possible through its emancipation from farm-yard manure, the value of which I recognised, and knew how to estimate perhaps more accurately than any one had done before me.

I regarded as the problem of our day the use of artificial manure, containing in itself all the efficient constituents of farm-yard manure.

I expressed my views on the principles of the preparation of artificial manure in two short papers—'*An Address to the Agriculturists of Great Britain, explaining the Principles and Use of Artificial Manures,*' and '*On Artificial Manures,*' Liverpool, 1845. These papers were circulated at that time both in England and Germany. I there said:—

"The duration of the fertility of a field depends on the amount of the mineral elements of the food of plants contained in it; and its productive power, for a given time, is directly proportional to that part of its composition which possesses the capacity of being taken up by the plants."—p. 10.

Again:

"It has been shown that the fertility of the soil depends on certain mineral substances. If the restoration of the fertility of exhausted fields, by means of the excreta of man and animals, depends on their proportion of these matters—if the effect of *accelerating* the vegetation depends on their proportion of ammonia—it is clear that we can only dispense with the latter (excreta of men and animals) when we provide all (their) efficacious elements exactly in those proportions, and in that form, most proper for assimilation by the vegetable organism, in which they are found in the most fertile soil, or in the

most efficacious manure. According to our present knowledge of the constituent (efficacious) parts of manure, I feel convinced that it is indifferent to the plants from which source they are derived. The dissolved apatite of Spain, the potash from feldspar, the *ammonia from the gas-works*, must exercise the same effect on vegetable life as the bone-earth, the potash, the ammonia, which we provide in (ordinary) manure." *

"We live in a time when this conclusion is to be subjected to a comprehensive and accurate trial, and if the result correspond with the expectations we are entitled to form, if animal excreta can be replaced by these efficacious elements, a new era of agriculture must begin."—p. 19.

At the desire of some friends I resolved, in 1845, to make the attempt to assist in realising these views. I communicated to them a series of prescriptions for the preparation of artificial manures for different crops, in which all organic constituents were excluded. The nitrogen required to increase the produce was to be added to them in the form of ammoniacal salts. In my paper on Artificial Manures I said—

"*Salts of Ammonia.*—It may be regarded as certain, that the nitrogen of plants is derived either from the ammonia of the atmosphere, or from the manure which is provided in the shape of animal excreta, fluid and solid; and that nitrogenous compounds exercise an effect on the growth of plants only in so far as they give up their nitrogen in the form of ammonia during their decomposition and decay. *We may, therefore, profitably replace all nitrogenous compounds by compounds of ammonia.*"—p. 26.

Again,

"*All manure which is to be used next winter, contains a quantity of ammonia corresponding with the amount of nitrogen in the grain and crops which are to be grown.* Experiments, in which I am at present engaged, will show whether in future the cost of this manure may not be greatly lessened by excluding the half or the whole amount of ammonia. I believe that this can be accomplished for many plants, as for clover and all very foliaceous plants, and for peas and beans; but my trials are not so far advanced as to prove the fact with certainty."—*Address*, p. 21.

The passages just quoted contain the most indisputable proof that the mineral manure, prepared according to my prescriptions, was to contain the constituents of the ashes of the plants to be cultivated, *with a certain quantity of nitrogen, in the form of ammoniacal salts corresponding to the composition of the crops, and the amount of nitrogen required by them.* And the proof that these manures contained ammonia as a constituent is found in the testimony of Mr. Lawes, which establishes the actual presence of ammonia in them. He says (Journal, vol. viii. p. 245), that he distinctly recognized ammonia by its smell.

The object in view was a complete revolution in agriculture.

Farmyard-manure was to be totally excluded, and all the mineral constituents removed in the crops were to be restored in the mineral manure. The usual rotations were to cease.

* Verbally, from the German original, which is printed in the second edition of A. Tetzhold's 'Lectures on Agricultural Chemistry.'

The question was to be solved: which of the cultivated plants required ammonia in the manure, and which of them could do without it. The manure was to give the means of raising, on one and the same field, uninterruptedly and yet without exhaustion, the same crop, whether clover, wheat, or any other, according to the wish or necessity of the farmer.

I most readily admit that the idea of these manures could only have arisen and taken root in the brain of a man of science, penetrated and inspired by the truth of his doctrines, but who had before his mind's eye not the actual state of things, but an ideal agriculture. It was folly to believe it even possible for a practical agriculturist to enter into these ideas, or to fancy that he could, or would convert all his fields into experimental fields for the sake of establishing fixed laws for agriculture; it was folly to call on others to enter on such an undertaking without any prospect of being able to devote to it the time and energy which were indispensable to its prosecution.

The just punishment of my imprudence has overtaken me, for I have been compelled to see that the very efforts I made to give to agriculture a scientific foundation, have only had the result of bringing agriculture into paths which, already trodden for centuries, have led to no permanent improvement.

In 1847 appeared (Journal, vol. viii. p. 226) the first paper of Mr. Lawes on Agricultural Chemistry, in which he endeavoured to prove, by the description of a series of facts, that the manure for wheat, prepared by my prescription, had been without effect, and was of no value to the farmer. He proceeded without interruption from me for some years, during which I was engaged in other investigations, till at last I found, to my no small surprise, that, encouraged by my silence, he had succeeded in changing the scientific direction of agricultural researches, and in bringing the subject back to the very point where I had found it and taken it up in 1840.

I had taught, *that the food of plants consists entirely of inorganic materials.**

That *carbonic acid, ammonia, and water, are inorganic compounds in the growth of plants: the hydrogen comes from the water, the carbon from the carbonic acid, the nitrogen from the ammonia.*†

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* 'Manual of Chemistry,' by Dr. Turner. Edited by Liebig and Gregory, 1842, p. 531.

† "Plants derive their nourishment exclusively from the mineral world. It is clear that the *first plants* must have done so; and, although the decaying remains of former plants *now* contribute to vegetation, we shall see that they do so *under mineral forms*, and not essentially; they promote vegetation, but are not indispensable to it.

"The *mineral* food of plants, then, consists of *carbonic acid*, *water*, and *ammonia*, all of which are obtained from the atmosphere; and of sulphur (sulphuric acid),

That *organic materials are parts or remains of plants and animals.*

That *organic manures are such as contain parts of plants or animals.*

That *inorganic manures are manures from which all parts or remains of plants and animals are excluded.*

These doctrines were admitted as truths by all scientific men, by all chemists, vegetable physiologists, botanists, and are still regarded as true.

How, then, did Mr. Lawes begin to raise doubts of the accuracy of my doctrines? From what position did he endeavour to persuade the farmer that the truths I had taught were errors? He did this in the simplest possible way.—(Journal, vol. viii. p. 240.)

"*Organic manures are those which are capable of yielding to the plant, by decomposition or otherwise, organic matter. Carbon, hydrogen, oxygen, nitrogen.*

"*Inorganic manures are those substances which contain the mineral ingredients, of which the ashes of plants are found to consist.*"

So that water (oxygen and hydrogen), ammonia and ammoniacal salts are, according to Mr. Lawes, organic matters!!

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phosphorus (phosphoric acid), alkalies, earths, salts, and metals, all derived from the soil." (Gregory's 'Outlines of Organic Chemistry,' 1843.)

I have quoted this passage to show that in 1843, and indeed long prior to that period, I had learned from Baron Liebig, and understood and taught precisely as he does in the text, his doctrine of the food of plants. I must also express my surprise that any one should not be aware that the atmosphere and all its constituents, including carbonic acid, water, and ammonia, are always regarded as mineral substances, and, as such, have their place in every system of mineralogy. The distinction made in the food of plants is not between inorganic and organic, for the whole is inorganic or mineral, but between atmospheric (gaseous) and terrestrial (solid). The term organic is only with propriety applied to such manures as contain parts of dead animals or plants. But even these, before they can serve as food for plants, must take inorganic forms.

It is true that chemists sometimes speak of the organic food of plants, meaning thereby carbonic acid and ammonia. But this, which is not a strictly correct mode of expression, has reference, not to the *nature* of these substances, but to their *origin*, which is generally, but not always, from the decomposition of organic substances. The more accurate term would be the *gaseous* food of plants, synonymous with *atmospheric*. It is well known that springs from great depths often contain both ammonia and carbonic acid, and that these substances are also poured into the air from volcanic sources, both active and extinct. To such supplies the term *organic* could not with propriety be applied, any more than to the carbonic acid and ammonia on which the first created plants must have fed. The passages above quoted from my 'Outlines' show plainly the opinions I have always held on these points, and prove incontestably that, in speaking of ammonia as an inorganic or mineral constituent of the food of plants, Baron Liebig, in his 'Principles,' has not had recourse to a *manœuvre* or *ruse*, but has simply stated the fact as it is understood among chemists. The error is on the side of his opponents, who have misapprehended the occasional use of the term organic, as applied to the *gaseous* food of plants, and have not clearly understood the distinction between the *terrestrial* and *atmospheric* food of vegetables.—W. G., Translator.

According to this definition, which is entirely unknown to science, a refutation of my doctrine was easy.

When I spoke of all progress in agriculture depending on our being able to replace farmyard-manure by its efficient inorganic constituents, Mr. Lawes, resting on his erroneous definition, proved that I had maintained *that we should exclude ammonia from the manure*, BECAUSE AMMONIA IS AN ORGANIC COMPOUND!!

And when, in my 'Principles,' p. 90, I said that his experiments included the proof that farmyard-manure (organic manure) could be replaced, in its entire efficacy, by mineral substances (for sulphate of ammonia and sal ammoniac, are mineral substances), he replies,—

"Thus, then, ammoniacal salts, sulphate of ammonia, and sal ammoniac, are to be classed as *mineral manures!* This is indeed begging the question: but a manœuvre so transparent as this would not even require notice, were it only addressed to the scientific reader." ('On some Points,' &c., Journal, vol. xvi. p. 447.)*

And when, in the same little work, as I had always done in my book, and as was indispensable to the understanding of it, I considered ammonia and the constituents of the ashes of plants as contrasted, in the sense of air and earth (atmospheric and terrestrial food of plants), Mr. Lawes ventures to assert, that *I* have regarded them as contrasted in his sense, and HAVE ALWAYS CONSIDERED AMMONIA AS AN ORGANIC SUBSTANCE, which, from my point of view, was a sheer impossibility; and he calls my explanation a *ruse!!* "The ruse," says he, "has not been entirely without success."—(p. 448.)

His last paper in this Journal is a carefully prepared attempt, not only to call in question my scientific qualifications in these matters, but also to cast suspicion on my veracity, as if a career of thirty-four years of the most earnest and laborious efforts, entirely devoted to science and to the welfare of mankind, were not a sufficient protection against such unworthy insinuations.

The history of agriculture will be a severe judge in these matters. I know well the defects and imperfections of my book, but no one shall ever be able justly to accuse me of not having endeavoured, with the best will and with all my power, to ascertain the truth, and to correct the errors into which I may have fallen. On the very first opportunity that offered, I admitted

* I must refer the reader to the last note for proof that the doctrine here represented as a manœuvre by Mr. Lawes was held and has always been taught by me, not only in 1843, but much earlier. In my Lectures, in common, I believe, with all teachers, I constantly represent the vegetable kingdom as building up organic matter from inorganic substances, and the animal kingdom (with decay and combustion) as reconverting organic substances into the inorganic food of plants.—W. G., TRANSLATOR.

the imperfection of my manure, and I expressed my regret that the idea which I had intended to realise had taken the form of a mercantile speculation. (*Letters on Chemistry*, 3rd edition, 1851, p. 482.)

After the third edition of my book had appeared, in 1843, no man in Europe ever imagined, up to 1847, that I had taught, *that the produce of soils is proportional to the mineral constituents supplied in the manure* ALONE, or *that I had advised farmers to give no ammonia in the manure applied to grain crops.* Men of science and agriculturists were aware, *up to the period when the first papers of Mr. Lawes appeared*, that I had laboured to direct their attention to certain fixed conditions of fertility in soils, the importance of which I pointed out the more strongly, the less they had been previously attended to. The effect of ammonia was *known* and *established.* Whether, in doing this, I committed an error, the reader can now decide for himself. All that Messrs. Lawes and Gilbert have collected from European and American journals in favour of their views of my doctrine is but a very small fraction of the literature which has appeared concerning it, and is nothing more than the echo of their own mistakes. It is not worth while to throw away a word more on these misrepresentations nor on the incomplete letter which I am said to have written to the 'Revue Scientifique et Industrielle,' in Paris, in 1847 (a periodical, the editor of which is unknown to me even by name), and the end of which alone has a rational meaning, "that, as soon as we can dispense with the bulky farmyard manure by the use of artificial preparations, the productive powers of our fields are in our hands." *

The experiments, published by Mr. Lawes in 1847, had originally for their object to test the efficacy of the manure prepared according to my prescription by Messrs. Muspratt and Co. of Liverpool.

Mr. Lawes calls the testing the efficacy of these manures testing the accuracy of my theory. The facts which showed that the produce of his experimental fields was not increased by these manures, he calls *proofs.* They prove, according to him, that manuring with the mineral constituents of wheat had no effect; and he concluded from this, that the supply of these con-

* During my visit to my friend Dr. Daubeny at Oxford, I became acquainted with Mr. Proctor of Bristol, a manufacturer of manures, who came to Oxford to tell me that he was indebted to my book for the success of his manures. He pays attention to the geological quality of the soils, and regulates accordingly, in accordance with my principles, the composition of his manures; and on his own fields he has obtained astonishing results. He has been fortunate enough, in every case, to satisfy the consumer. I caused my son Hermann, who is a practical agriculturist, to travel to Bristol; and what he saw there agrees perfectly with the preceding statement, communicated to me by Mr. Proctor.

stituents from without was of no value for his fields or for the soil of England generally; and as these manures contained the constituents of the ash of wheat in the quantity required for a crop, and in the proportion found by analyses to exist in the ashes of the wheat plant, he maintains that his unsuccessful experiments with these manures prove that the only scientific basis for judging of the value of a manure, namely, its chemical composition, is fallacious, and does not hold good in practice. Then he tells us what his practice is. The soil, in his practice, was to receive, not the same elements, and in the same proportions, as those selected from the soil by the plant, but proportions dictated merely by fancy, and, in a chemical sense, mixtures destitute of all principle.*

In 1846, when Mr. Lawes made his experiments with my manure for wheat, he proceeded on the impossible supposition, that a field, which by a series of crops had been brought to the last degree of exhaustion,† consequently after he had removed from it six, eight, or perhaps ten times the quantity of mineral constituents required for a crop, could be brought to a maximum of fertility by restoring the mineral constituents of one crop, that is to say, the sixth, eighth, or tenth part of what had been removed. He manured this field with 448 lbs. of the manure for wheat prepared by my prescription, which contains less than half its weight of the constituents of the ash of wheat; that is, he added 1 grain of ash constituents for 4 cubic feet of soil, reckoning it to the depth of 12 inches. And he wonders that this field did not yield a maximum of produce. With this minimum of manure he might keep up permanently a medium produce of the field, but more than this could not rationally be expected from this experiment. Had he begun by adding six, eight, or ten times the quantity, and continued the experiment by adding

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* As a historical curiosity, I here subjoin some of these mixtures:—

1.	350 lbs.	superphosphate of lime.	Or, 2.	300 lbs.	pearlash.
	84 „	phosphate of magnesia.		200 „	soda ash.
	65 „	phosphate of soda.		100 „	sulphate of magnesia.
	75 „	phosphate of potash.		200 „	calcined bone-dust.
	65 „	phosphate of ammonia.		150 „	sulphuric acid.
	112 „	silicate of potash.		200 „	sulphate of ammonia.
	145 „	rape cake.		250 „	muriate of ammonia.
	896 lbs.			1350 lbs.—*Journal*, vol. xii. p. 19.	
Or,	300 lbs.	superphosphate of lime.	Or,	350 lbs.	superphosphate of lime.
	420 „	phosphate of magnesia.		325 „	phosphate of soda.
	720 lbs.			675 lbs.—*Journal*, vol. viii. p. 19.	

† The field selected for the purpose had been reduced to the lowest state of fertility.—*Journal*, vol. viii. p. 7.

annually the quantity corresponding to one crop, the result would probably have been very different.

And, although Mr. Lawes observed that the small quantity of my manure which he used, by simply increasing the proportion of ammoniacal salt contained in it, and by the addition of rape-cake, contributed to increase the produce of his fields, and this, in the majority of cases, to a greater extent than he was able to do by the use of his fanciful mixtures, with equal additions of ammoniacal salts and rape-cake, he yet maintains that he has proved, that the principle of the composition of my manure is fallacious, and does not hold good in practice.

The main question—that of the comparative permanence of the increased produce, during a series of years, under the use of manures prepared according to the results of analysis, and under that of the mixtures imagined by him—has been entirely overlooked by Mr. Lawes. He never thought of inquiring whether the origin of the difference in the efficacy of these manures for wheat, in relation to time, the excess of ammonia and rape-cake being excluded, should not be sought for in their peculiar form and quality. He thought that the facts observed by him proved the fallacy of my theory, as if he had had any the most distant idea of testing the truth of that theory. He made hundreds of trials with his own mixtures, varied in every possible way. Why, then, did he not make as many trials with mixtures prepared on my principles, and varied in the same manner? This a man of science would certainly have done, before he condemned my theory.

If a kind Providence, in compassion to agriculture, were to send down on our fields twice as much ammonia as is required for a full crop of wheat, this would not be enough for Mr. Lawes. Were he permitted to express his wishes in this matter, he would address to Providence the request that to his fields and to his mixtures a fivefold supply might be vouchsafed.* It is only then that he can feel sure of obtaining something more than one-half more than his fields, without any supply of ammonia, produced. Such views would be simply ridiculous, were they not so injurious in their consequences.

* "I am inclined to think that, for practical purposes, we may assume 5 lbs. of ammonia to be required for the production of every bushel of wheat beyond the natural yield of the soil and season" (*Journal*, viii. p. 246). Again (p. 482), "We do not intend to enter fully into the question of the accuracy of this estimate, but we may observe, in passing, that among the plots, the history of which we have given in the preceding pages, down to the last harvest, there is not one, even under the best conditions as to (his, Mr. Lawes's) artificial mineral supply, where the ammonia, on an average of seasons, has given an increase equal to our estimate."

My views are different and may be thus expressed:—A certain mass of silver and gold circulates in the world, and the art of becoming rich consists in knowing the way to divert, from the main stream, an additional brook to one's own house. In like manner, there circulates, in the air and in the soil, a relatively inexhaustible quantity of the food of plants; and the art of the farmer consists in knowing and using the means of rendering this food efficient and available for his crops. The more he is able to divert from the moving stream (the air) to the immoveable promoter of his production (the soil of his fields), the more will the sum of his wealth and of his products increase.

I had advised farmers not to bestow their chief attention on that element of the food of plants which the heavens constantly shower on our fields, but rather to care especially for those constituents, which are not restored spontaneously, or without our assistance; and considering that I was well aware what enormous quantities of ammonia are contained in the soil, which ammonia was inefficient if the conditions of its efficiency were wanting, it is easy to see why I was led to look for the causes of the efficacy of fallow in other quarters, and not in the increase of the amount of ammonia in the soil.

In direct contradiction to my opinion, and after they had premised (p. 488) that in my book, and especially in the chapter on fallow, I had not said a single word of the accumulation of atmospheric food for plants, that is, of nitrogen, in the soil, these agricultural chemists assert as follows:—"We maintain (p. 487) that it is by the amount of this accumulation of available atmospheric food of plants *within the soil*, rather than by the amount of liberated (proper) soil constituents, that the increased produce of grain will be measurable." Again (p. 488): "We have ourselves, on more than one occasion, called attention to the former influences, and also to the fact that a study of the properties of the soil in relation to the atmospheric food of plants promised to be of more value to agriculture than that of the mere determination of its percentage composition in the mineral food of plants." And as they find, in my 'Principles' (p. 106), a sentence which, verbatim from p. 82 of the German edition, is as follows: "But to prepare the soil, by art, so that it is enabled to collect from the atmosphere and the sources offered to plants by nature a maximum of nitrogen;—this is a problem worthy of scientific agriculture;" they add (p. 488), "We are happy to have now the sanction of Baron Liebig himself." They thus endeavour to make others believe that they have taught me the fact of the presence of ammonia in the soil (which, ten years ago, I determined in twenty-two different soils), and that I ascribed to the ammonia which the soil acquires in fallow some specially predominant influence.

But Messrs. Lawes and Gilbert have, without being aware of it, supplied the most decisive proof that the accumulation of ammonia in the soil, in one year, has no influence on the crop in the succeeding year. They manured a field in 1845 with 336 lbs. of ammoniacal salt, of which no more than 72 lbs. could be employed in the increase of produce obtained. The residue, 254 lbs., which remained in the soil, had no influence on the crop of 1846. After a new manuring with ammoniacal salt, there was a new residue of 206 lbs.; but even the two together (= 634 lbs.) was equally without effect in 1847. At last the residue of ammoniacal salt in the soil amounted to 1192 lbs.; but even this had lost all influence. In all these trials with ammoniacal salts, even when an enormous excess was used, the accumulation of ammonia in the soil was found to have no effect in the following season.

But if in this way clear proof is obtained that the accumulation of ammonia in the soil does not increase its fertility in the following year; if, moreover, the ammonia be added to the soil in the form of a non-volatile salt, how can it rationally be supposed that the quantity of ammonia which is possibly conveyed to the soil by the air and rain, which is from three to five times smaller, can have a perceptible influence on the fertility of the soil? when we know, in addition to all this, that the soil contains many hundred times, nay often a thousand times, as much ammonia as is required for a full crop of wheat. From this want of effect, these writers draw the conclusion, *that the ammonia has evaporated and has been dissipated through the leaves and stalks!* But this conclusion is not *a fact;* it is a pure fancy; and has been imagined in order to save their so-called theory. In a similar way do they proceed in a series of experiments on the cultivation of turnips. They manured a field for several years with superphosphate of lime. In 1843 it received 504 lbs.; in 1844, 560 lbs.; and in 1845, 1232 lbs.; in all, 2296 lbs. of superphosphate of lime. In the three crops of turnips there were removed from the soil, in each, about 112 lbs. of superphosphate, in the three years therefore 336 lbs., and there remained in the soil 1960 lbs. of superphosphate for the crop of the fourth year. But now was presented the strange circumstance, that this field, though it contained after the third crop, nearly four times as much superphosphate as was supplied in the first year, yet required to be manured, in the fourth year, with 280 lbs. of superphosphate, in order to yield a fourth crop. While 504 lbs. in the first year had a most marked effect, 1960 lbs., present, after the third crop, had no effect on the crop of the fourth. There is no room for supposing a want of phosphoric acid; for the soil contained, in the fourth year, four times as much as in the first, and yet lost its productive power. The phosphoric acid lost its efficacy! This case is quite parallel to

that of the manuring of the wheat field with sulphate of ammonia. The sulphate of ammonia in that instance, like the phosphoric acid in this, lost its influence on the crop of the succeeding year, and if facts can prove an erroneous opinion, the arguments used in the case of the wheat field, when employed in that of the turnip field, will prove that the phosphate of lime must, like the sulphate of ammonia, have evaporated through the leaves; for in no other way could it have disappeared or been lost.

It never occurred to these observers to inquire, whether the sulphuric acid, in the superphosphate, had any effect, although they might have known, from the analyses of the ashes of turnips by Way and Ogston, that turnips extract from the soil, and unquestionably therefore require, about 50 per cent. more of sulphuric acid than of phosphoric acid.

Two of these experiments favour the opinion that the chief share, in the action of the superphosphate on turnips, belongs to the sulphuric acid.

In 1844 they manured the plot No. 13 with 400 lbs. of bone-dust, 258 lbs. of sulphuric acid, and 134 lbs. of common salt; and they obtained 14 tons 10 cwt. of turnips, with 6 tons 11 cwt. of leaves.

In the same year they manured the equal plot No. 9 with 400 lbs. of bone dust and muriatic acid (= 268 lbs. of sulphuric acid), and obtained 9 tons 9 cwt. of turnips, with 4 tons 6 cwt. of leaves. *The result of these two experiments is clear and incontrovertible. The two plots received the same quantity of phosphoric acid in the same state of solubility; both also received chlorine; but that which received no sulphuric acid yielded 5 tons of roots, and 2 tons 5 cwt. of leaves* LESS *than the other, which was manured with superphosphate of lime and* SULPHURIC ACID.

The enormous deficiency in the crop of No. 9 cannot therefore be ascribed to a want of phosphoric acid; as little is it due to the presence of chlorine; and it is evident that the cause of the difference must lie in the sulphuric acid, excluded from No. 9, and that this sulphuric acid has a principal share in the effect of superphosphate of lime on turnips.

Another of their experiments is not less remarkable. In 1843 they manured No. 1 with 12 tons of farm-yard manure; No. 12 with 2½ cwt. of superphosphate of lime, 2 cwt. of rape meal, and 1 ton of sulphate of ammonia; and No. 23 with 15 bushels of clay and the ashes of weeds. The produce was—

	tons.	cwt.	lbs.
1. No. 1	9	9	2
2. No. 12	11	7	3
3. No. 23	11	1	3

To appreciate justly the significance of these experiments, we

must remember that Messrs. Lawes and Gilbert ascribe the effect of superphosphate of lime to the *phosphoric acid*, and that of farm-yard manure *to the organic constituents of the straw*, and, as we might expect from them, without their having ever made an experiment with *phosphoric acid alone*, or with *straw alone*. How do they explain the effect of the clay and weed ashes, which gave a heavier crop than the farm-yard manure, and one almost equal to that yielded by the superphosphate? There can here be no question of free phosphoric acid, nor of an excess of phosphoric acid, nor even of an error of the press. The answer is (vol. viii. p. 17)—"This is a curious result, and indicates that certain mechanical as well as chemical conditions of soil are essential to a favourable and healthy development of the organs of collection."

To this experiment, the only one, of all made by them, which deserved to be continued and more accurately studied, no farther attention was paid. Possibly it might have happened that this experiment might have led to the confirmation of the fundamental proposition of my doctrine.

To the specimens of just reasoning given by Messrs. Lawes and Gilbert, I shall add another, from a different quarter, which is not less striking.

Messrs. Chevaudier and Salvetat made, in 1852, certain researches (' Ann. de Chim. et de Physique,' 3rd series, vol. xxxiv., p. 307) in order to discover how it came to pass, that, of two meadows, the one gave constantly a heavier crop of hay than the other. Both were meadows of irrigation, but they received the water from two different sources. One of these was called the good spring (*la bonne source*), the other the bad spring (*la mauvaise source*). That the great difference in the produce of the two meadows depended on the fact that they were irrigated, one with the good, the other with the bad spring, was a point on which these two chemists had not a shadow of doubt. For the majority of agricultural chemists, in all countries, resemble each other in this, that they never entertain any doubt of the truth of their opinions.*

Without first trying whether the water of the good spring, if used to irrigate the inferior meadow would increase its produce, or whether the water of the bad spring applied to the better meadow would diminish its produce; without first deciding this essential preliminary question, Messrs. Chevaudier and Salvetat began, with an industry and perseverance which excite admiration, to measure the water of the two springs employed to irrigate

* Chemists will think the style of Mr. Lawes very remarkable. The tone in which he instructs me in purely chemical questions, is precisely that which a schoolmaster adopts in dealing with a stupid, obstinate, and ill-mannered boy.

the meadows. The good meadow received annually 255,744 tons of water, the other 164,231 tons. The water was now analysed, and its volatile and fixed ingredients were determined. The hay of both meadows was subjected to ultimate analysis, and no difference was found in the composition of the hay. The water of the bad spring contained 20 per cent. more of mineral substances and 30 per cent. more of organic substances than that of the good spring. What then was the cause of the extraordinary difference of produce? They found that the water of the good spring contained, in 1847, 15 kilogrammes; in 1848, 23 kilogrammes, of nitrogen, more than that of the bad spring; and the explanation, corresponding to theory, was at once secured.

The 23 kilogrammes, or 48·3 lbs. of nitrogen, which the one meadow received in the water, more than the other, was pointed out by these chemists as the cause of the increased produce of that meadow, which increase amounted to 14,440 lbs., or 6·44 tons of hay.

In other words, the one meadow produced, in the form of hay, 144 lbs. of nitrogen more than the other (calculating the nitrogen in hay at 1 per cent.), and, at the same time, four times as much potash, phosphoric acid, silicic acid, &c., as were contained in the produce of the inferior meadow. And the 48·3 lbs. of nitrogen which produced these miraculous effects was supplied to the meadow in the form of irrigation with water, containing in 77 gallons 1 grain of nitrogen more than the water of the other spring. Whether 1 part of ammonia dissolved in 6½ millions of parts of water would have raised the produce of the inferior meadow to the level of that of the better one, was of course not tried, for the object of these chemists was not to ascertain the truth, but to prove their theory; and, in this point of view, the soil and its constituents had evidently nothing to do with the question.

We may see by this example to how great an extent the theory which teaches that nitrogen is the turning point of agriculture, disturbs the judgment and confuses the understanding of really intelligent men; and that the prodigious expenditure of labour in chemical analyses in such circumstances is nothing but outward show and stage decoration; it is the shell of a fruit without kernel or contents. No one certainly will expect of an agricultural chemist that he should have studied Lord Bacon's work 'De Augmentis,' or his 'Novum Organum,' before he begins to make experiments; but sound reason demands, that when a man draws conclusions and makes inferences he should first take all possible pains to establish accurately his premises and data. If he neglect this, he can effect nothing of any value, how great soever may have been the outlay of labour, time, patience, and skill in his experiments.

We must never forget that any change in our methods or in the direction of men's thoughts, whether in science or in arts or professions, can only be very gradually effected, and that the refutation of errors which are held as truths is infinitely difficult, because truth itself appears to be error. In all ages and on every such occasion the old falsehood has stood at the door when a new truth desired admission. The true doctrine is to be recognised by this, that it has roots and that it grows.

To myself, in regard to the chemical theory of agriculture, I believe I may apply, without presumption, what Macaulay says of Bacon:—

"He was not the maker of that road; he was not the discoverer of that road; he was not the person who first surveyed and mapped that road. But he was the person who first called the public attention to an inexhaustible mine of wealth, which had been utterly neglected, and which was accessible by that road alone. By doing so he caused that road, which had previously been trodden only by peasants and higglers, to be frequented by a higher order of travellers."

Munich, April, 1856.

MISCELLANEOUS COMMUNICATIONS AND NOTICES.

I.—*On 'Ridge-and-Furrow' Pasture Land, and a method of levelling it.* By CHANDOS WREN HOSKYNS.

TO THE CHAIRMAN OF THE JOURNAL COMMITTEE.

THE only case in which I have ever known of harm mixed with the good done by the draining-tile has been in that of old dairy pastures lying in 'ridge and furrow.' In most dairying districts there is, as you know, a great deal of such old pasture, much too valuable to break up, and which has been lying in that form perhaps for centuries, always ready in a hot summer to burn, upon the ridge, and always swampy at winter time, and a nursery of unwholesome aquatic grasses, in the furrow. The cheese-and-butter-making qualities of such land, in the districts I am speaking of, stand nevertheless so far above any other use it could be applied to, and are so impossible to *reproduce*, that the idea of breaking up is, and with truth, regarded as an insult to the *genius loci*. Every soil has its native characteristic; and that of the land I am describing (of the 'clay-farm' variety) is beyond all question less responsive to the plough than to the milk-pail.

But having been *laid down* (if so it can be termed) long before the drain-tile was in common use, it is, from its form of surface, stereotyped to perpetual suffering from the alternate evils I have described. And when you come to the attempt to cure the one by drainage,

"Incidis in Scyllam cupiens vitare Charybdim,"

you make the other *worse*. This is no fanciful 'complaint:' it is literally and experimentally true. And its truth is due to the obvious fact, that by this artificial corduroying of the surface you have put yourself out of nature's court, and out of the benefit of her undeviating laws. In other phrase, you have altered the balance of percolation and capillary attraction, to which good drainage owes its efficacy and equality of action. The tenant tells you that his best dairy-piece is spoilt by being laid *too dry!* Strange as the words always sound in a wet clay district, they turn out to be more fully verified every year; and the stiffer the soil, the more true they are likely to be, because in such soil the roots of grasses on the sun-baked ridge have more difficulty in descending for moisture below the *mean level.*

In fact, after drainage, the mean level of the ridge-and-furrow

(by which nature had before striven for a kind of give-and-take compensation of too wet and too dry) is gone; the crown of the ridge is isolated, raised out of reach of the re-active moisture from below, that supports the level herbage of a meadow in long droughts, and confirms the benefit of the draining-tile under a level surface by the increased 'capillation' set up in the soil. This, I repeat, is lost, and worse than lost, upon the convexities presented by the ridge-and-furrow.

The experience of this evil, now well-established, in the quarter I speak of, has led me to try several methods of levelling the surface of such lands—I mean, of course, without breaking up; and I am tempted to submit to you a mode of doing this which I have been led to, as the most efficacious and economical I can discover, and which has the advantage of greatly improving both the amount of pasture and its dairying qualities. To some it may not be new—it is difficult in agriculture to find anything that is so; but it is by no means difficult to name many things that are "not new" and "not bad," which are nevertheless unknown and unadopted where they are most wanted; and at least I can say that, simple as the method is I shall try to describe, I have never seen it attempted elsewhere; and even by some who have all their lives been longing to level park land and pasture fields that they have regarded as an eyesore in their ridge-and-furrow outline, the cure has been considered hopeless without either enormous expense or the fatal recourse to breaking up.

The plan is this:—Take a common broad-shared ridging-up plough, without the mould-boards on either side (one of Bentall's answers the purpose very well); let the horses be led carefully along the centre of every *alternate* ridge, splitting and slightly under-paring, without turning, the turf on the crown. Then, by hand-work, let the turf be rolled over (in widths of about two feet each) towards the furrow on either side, to a point a little beyond the shoulder* of the ridge, so as to expose the soil on the upper half of the ridge. Plough this soil, opening out a furrow in the centre, and gathering towards it, as is done in the common "gathering up" for wheat-sowing. Then, by spade-work, throw out the soil thus loosened in equal portions upon the adjacent furrows right and left. Dig the second soil (it is not *subsoil* in the true sense of the word, but the original top-soil † of that place), cutting it tolerably fine, and roll back the turf upon it. Bear always in mind that this is only done upon each *alternate* ridge: but that the soil thus thrown out and distributed will lie upon *every* furrow, which will thus receive upon their surfaces a dress-

* The point equidistant from the crown of the ridge and the bed of the furrow.
† I prefer throwing *this* into the furrows, casting *forward* the top soil.

ing of *half* the soil originally taken from them. This may be done any time during the winter, and the rougher it is thrown on the better. In the dry weather of March, let this soil be rolled and bush-harrowed up and down the furrow. The herbage soon gets through it, and comes up with the utmost luxuriance. In two summers the soil will have entirely disappeared in the furrows, and the grass have acquired a deep fresh greenness that shows how the heavy dressing of soil has refreshed it: that on the ridge being equally benefited by the under-digging.

Leaving it, then, for a couple of summers or more, according to discretion, proceed the following or any succeeding winter in the same manner with the alternate ridges that remain. The field is then level; the whole of the soil in its *original* place, from which it was formerly removed by the plough; and the whole of the pasture refreshed to a degree which, independently of the object of levelling, exhibits the two greatest improvements of which old turf-land is susceptible, namely, under-digging and top-dressing with soil.

Before I come to the question of expense (which will have appeared greater than it really is in practice, from the necessary length and minuteness of a description detailed enough to work by), let me just say that the work may be done in the same time, and with still better effect, if instead of the alternate furrows every *fourth* furrow be in the first year operated upon, and the soil cast over *two* furrows on each side instead of one, thus lightening the dressing, and not endangering the least smothering of the grass, or lateness of herbage. Every winter, or every alternate winter, the remaining ridges may be proceeded with; so that the mean level of the field may be attained by a process of top-dressing suited to the circumstances, and less costly than that so commonly seen of hauling soil from considerable distances, making and turning it in "buries," and recarting it over the field.

In this latter plan, the spade-work is employed upon only *one eighth part* of every acre in each year, or each alternate year; the ridges disappearing gradually, and those that remain appearing less and less elevated as the dressings of soil gradually raise *all* the adjacent furrows. In adopting the latter course I have found it lighten the work if the spadesman throw the heavier dressing upon the nearer furrow, casting only every third spadeful upon the further one. When he comes to do the intermediate (alternate) ridge, the following winter, he adjusts the proportion by doing the same again, two spadefuls falling this time where the *one* fell before.

And now, in approaching the important question of cost, let me premise that, in order to reduce the ridges of a field to its mean level, a much less quantity of soil is actually required to be

moved than the eye leads one to suppose. The eye, measuring always from the bed of the furrow to the crown of the ridge, sees the evil double. Six inches of soil, moved from the one space and laid on the other, making a foot of perpendicular height between the two, constitutes a high ridge. Obvious as this is, the illusion is constantly recurring out of doors; and it is not until the spade begins its work, and every spadeful does its double office at one cast, sinking the high and raising the low as it falls, that the exaggeration is practically detected. This would apply, if even *all* the ridges were operated on at once; but as this would smother the grass in the furrows, the labour is again subdivided by taking only the alternate ridges, and casting half the soil on either side; and again still farther, when by taking every fourth ridge only, the furrow is insensibly raised by repeated top-dressings, averaging only an inch and a half of soil each year, and at the end of four years still amounting to only half the depth of that difference of altitude that originally met the eye. But whilst the action on the furrows is thus gradual, each ridge when done, as its turn comes, is done for ever, being reduced at once to the medium level, which the furrows have not yet reached. Yet when all the work is completed, the spade has been employed only upon *half* the land; the other half having done itself, so to speak, by the fall of every spadeful taken up.

Against this, however, is to be put the digging of the second layer of soil left upon the ridge after removal of its surplus. But any one who has seen the after effect of this under-digging upon the herbage will admit that this part of the process, any more than the top-dressing bestowed upon the furrows, is not to be charged as unproductive labour. I remember seeing some years ago the report of an experiment in the actual paring, under-digging, and replacing of some old turf, in which the process, expensive as it must of necessity have been, was described as repaying the outlay. This I should doubt, though from experience I can bear full witness to the extraordinary improvement it produces both in the quantity and quality of the grass. Still the testimony is good, *valeat quantum*, in relief of the incidental charge which the present case involves for the same operation upon one fourth or (in the latter mode described) *one eighth* of the land each year.

The bill of costs stands thus:—

	£.	s.	d.
Paring and rolling back turf on one quarter of an acre, and rolling again into place	0	12	6
Ploughing top-soil, ditto (quarter acre)	0	2	6
Throwing forward top-soil, digging second soil, and casting into adjacent furrows (ditto)	0	15	0
Total cost, 1st year	£1	10	0

The repetition of this process, after the prescribed lapse of a couple of years, will bring the total outlay on *the acre* to about 3*l*., a considerable expense, no doubt, but the increased luxuriance of the herbage appears to me to nearly repay it; though it will be observed that I am not speaking of it in the light of an ordinary farming operation.

In cases where I have, on ploughing the exposed soil of the ridge, found the subsoil inferior, I have *thrown forward* the top-soil (as in double-digging), and cast out the *second* spit of earth on the adjacent furrows, where its exposure, with crushing and harrowing, quickly mellow it; and I have never, in the worst case, seen any but good effect upon the undergrowth of herbage in the furrow. Of course, I am speaking throughout of grass-land which has been drained, and where the crown of the ridge is found too dry.

Wroxhall Abbey, March, 1856.

II.—*Contagious Disease among Cattle in Mecklenburg.*

Foreign Office, June 12th, 1856.

SIR,—I am directed by the Earl of Clarendon to transmit to you, to be laid before the President and Council of the Royal Agricultural Society, the accompanying copy of a Despatch from Colonel Hodges, Her Majesty's Consul-General at Hamburg, enclosing a Second Report from the British Vice-Consul at Lübeck, respecting the contagious disease that has broken out among the cattle in Mecklenburg. I am, Sir, &c.,

E. HAMMOND.

The Secretary of the Royal Agricultural Society.

Lübeck, May 30th, 1856.

SIR,—In my Despatch of the 17th instant I had the honour to report, that in consequence of a contagious disease having broken out among the horned cattle in Mecklenburg, the Lübeck Government had issued sanatory regulations, to be enforced in case the disease should appear within the Lübeck territory, and, as a precautionary measure, had enjoined that no horned cattle should be allowed to enter the Lübeck territory from the Duchies of Mecklenburg-Schwerin and Mecklenburg-Strelitz, except such as were certified by the competent authorities to be entirely free from the disease.

After consulting several German works on the subject, and, among others, the excellent '*Thierheilkunde*,' by Professor Baumeister and Dr. Duttenhofer (1 vol. 8vo. Stuttgart, 1844), I am impressed with the conviction that the measures adopted to pre-

vent the introduction of this fatal disease or murrain into a given country cannot be too stringent or too rigorously enforced.

In the notification issued by the Lübeck Government, the Mecklenburg murrain is termed "a pulmonary disease" (*Lungenseuche*) among horned cattle. There are, however, two kinds of murrain described in the works which I have consulted: one, called in German *Rinderpest*, or *Rindrichseuche*, or *Löserdörre*, and which might appropriately be termed THE STEPPE MURRAIN; the other called *Lungenseuche*, or *Lungenfäule*, or *Lungenbrand*, and which may be termed in English THE PULMONARY MURRAIN. Both are equally contagious and almost equally fatal; and, in a sanatory point of view, may, in fact, be regarded as identical. The following account, condensed from the articles in the works consulted, will afford the necessary information respecting them:—

THE STEPPE MURRAIN.—*Origin.*—The original seat of this fatal disease is the steppe land of Southern Russia, where it first appeared, or, at least, was first noticed and scientifically described towards the middle of the seventeenth century, since which it has been endemic among the horned cattle of the steppes, both of the Russian steppes and the steppes of Siberia and Tatary (commonly, though erroneously, called Tartary, and still more erroneously *Independent* Tartary), and has at various times become epidemic and spread to Hungary and Poland, and thence to Germany and Western Europe. It has been calculated that during the last century alone this murrain carried off 28,000,000 head of cattle in Germany, and in the whole of Europe (including Russia, but exclusive of Siberia and Tatary) upwards of 200,000,000. It has frequently prevailed in the Duchies of Schleswig and Holstein, especially from 1774 to 1781, when 150,000 head of cattle perished. In 1813 it again broke out in the Duchies, but was speedily checked and eradicated by the stringent measures and police regulations adopted by the Danish Government.

Symptoms.—From the taking or first attack of the disease, to its breaking out, seven days generally elapse, during which the cattle attacked are at times more dull, at times more lively, than usual. They hold down their heads, butt with their horns, frequently low, and, when driven to water, often jump about and become quite unruly. Sometimes they take their food and chew the cud with unusual quickness; sometimes not at all. Towards the fifth day, respiration somewhat affected, an unfrequent but short dry cough, back somewhat bent, and, when stroked, unusually sensitive. Eighth day: disease breaks out: hair stands on end; eyes fixed and dull; nostrils and muzzle hot and dry; inside of mouth hot and of a deep red; gums spongy and swollen, and marked with red spots front teeth loose; hide hard, like parch-

ment, and adhering to bones; ears and horns febrile, with alternations of great heat and cold; respiration accelerated, but deep, with visible motions of nostrils; cough more frequent, violent, and ringing; pulse hard, from seventy to seventy-five pulsations per minute; appetite entirely gone, though some cattle, in this stage of the disease, take their food as usual; most of them are, however, unquiet, toss up their heads, shiver, and gnash their teeth; if stroked on the back, they bend down and low mournfully, seldom lie down, and, when they do so, instantly get up again; void excrements frequently, urine seldom; in voiding excrements, back much bent, tail turned high up, animal turning its head towards the rump and striving to lick it; excrements dark-coloured, hard, dry, ustulatious pellets; urine red and clear; fever intenser in the evening than in the morning, and, as it increases, animal shakes its head, shivers, gnashes its teeth, and refuses to take food. Cows give but little milk, which is, however, more creamy than usual.

Ninth and tenth day: fever becomes putrescent, small white pustules break out in the mouth, which, when they burst, leave dark red spots that easily bleed; similar pustules appear in the nostrils and between the clefts of the hoofs; hide in some places intumescent; eyes dim, eyelids hanging down; from the eyes flows a pituitous lachrymose humour, which dries up at the edge of the nostrils; nostrils exude a dingy-white viscous humour; tongue shrivelled, and often hanging loose out of the mouth, covered with an impure saliva; teeth loose; mucous membrane of mouth sebaceous, and falling off in large pieces; breath putrid and nauseous; muzzle hard and cracked, like the bark of a tree; hair rough and without the least gloss; parchment-like hide, now covered in some places with nodules, on which appear small pustules containing a yellowish humour; pustules burst, humour dries up, and a mangy eruption ensues, commonly on the back, anus, and udder; rumination ceases; animal reduced to a skeleton; pulsation 80 to 100 per minute; respiration quick, wailing, and painful; alternations of heat and cold; on the side of the more diseased lung heat greater and of longer duration; excrements, previously hard, are now soft, loose, and watery. This state is followed by choleraic diarrhœa, with acrid, purulent, brownish, or blackish green fæces, smelling like carrion. If constipation now ensues, the animal swells up and soon dies. If, instead of diarrhœa, a more natural evacuation of the bowels takes place; if the animal warmth becomes more normal, respiration more free, pulse slower and fuller; if the hide scales off, and regularly running sores (abscesses) are formed, recovery may be expected. This is, however, very seldom the case, the above-mentioned symptoms generally increasing after a short illusory

amelioration. The animal then staggers, falls, rolls on the ground, gasps for breath, swells up, is seized with convulsions, and dies.

Treatment.—In respect to the treatment of the disease, writers differ materially, some recommending bleeding, others strongly condemning it. Professor Baumeister and Dr. Duttenhofer prescribe, as a remedy in the *first* stage of the disease, calomel 2 dr., burnt acorns ½ oz., marsh-mallow ½ oz., made up with honey into pills, two or three of which to be administered daily; but another writer (Marteus) candidly admits that none of the innumerable remedies hitherto prescribed have been of much efficacy.

Contagious character.—All the writers I have consulted concur in regarding this murrain as in the highest degree contagious. Hide, hoofs, horns, in short every part of the animal, as well as the excrements, are impregnated with the virus, which is moreover so volatile that it may be communicated at the distance of twenty paces. In the open air the virus loses its force in six days, but when closed up retains it for months. The contagion is limited to horned cattle—other animals, as well as human beings, not being affected by it. The mortality among the cattle attacked by the disease averages in the steppes 50 per cent.; in Germany from 80 to 90 per cent. During the first stage of the disease the flesh retains its natural colour, and may be eaten without detriment. It afterwards becomes pale, withered, and nauseous, and is, of course, unfit for food.

Precautionary measures.—When the disease breaks out, or is in an adjacent country, the most stringent regulations to prevent its spreading or introduction should be instantly adopted and duly enforced by the competent authorities. The most effectual way of checking the disease would be to slaughter the cattle attacked by it at once. But whether they be slaughtered or die of the disease, their carcasses as well as their excrements should be burnt or otherwise destroyed, or at least thrown into deep pits, dug for the purpose, and carefully covered up with earth. The hides, if preserved, should be tanned as soon as possible. The clothes of the attendants, the stalls, cowhouses, &c., should be purified with chlorine, and the cowhouses well ventilated before other cattle are stalled in them.

THE PULMONARY MURRAIN.—*Origin or cause.*—Marshy meadows, bad and too irritating food, as frozen potatoes, &c., want of fresh water, removal to another district, and, above all, infection.

Symptoms.—The disease is described as an induration, with a sarcose change in the texture of the lungs. The symptoms are much the same as those of the steppe murrain; in fact so similar, that the two diseases are often confounded. The first stage of the

disease, indicated by a short dry cough, may, however, last for weeks. During this period the animal may be cured. In the second and third stages the disease is as fatal as the steppe murrain, takes also much the same course, and ends in the same manner with œdematous swelling, convulsions, death.

Contagious character.—The pulmonary murrain is fully as contagious as the steppe murrain. In a sanatory point of view the two diseases may, therefore, be regarded as identical. Hence the precautionary measures above recommended are applicable to both.

Although the disease that has broken out among the horned cattle in Mecklenburg seems to be regarded as the *pulmonary murrain*, it may perhaps be the real *steppe murrain* which is now raging among the cattle in Poland to a fearful extent, notwithstanding the stringent measures that have been adopted by the Russian Government for putting a stop to it.

I have, &c.,
(Signed) T. A. Blackwell.

Colonel Hodges, C.B.
&c. &c.

III.—*German Wool Fairs, Midsummer*, 1856.

Foreign Office, July 11th, 1856.

Sir,—I am directed by the Earl of Clarendon to transmit to you, to be laid before the Council of the Royal Agricultural Society, the accompanying copy of a despatch from her Majesty's Consul-General at Leipzig, enclosing a report upon the Wool Fairs of Germany.

Lord Clarendon thinks that this information may not be uninteresting to the Society. I am, Sir, &c.

The Secretary of the
Royal Agricultural Society. Shelburn.

Report on the Leipzig and other German Midsummer Wool Fairs of 1856.

The Leipzig Wool Fair was held this year, as usual, on the 13th and 14th of June, and was well attended, principally by German purchasers. The central situation at Leipzig among the cloth manufactories of Saxony and Prussia makes it a convenient place of resort for wool buyers, though the supply is always small in comparison with the quantities brought to the great fairs of Berlin and Breslau. On this occasion the stock of wool at market was

39,792 stone* (or 7958 centners), being 14,947 stone more than the quantity of last year's fair. The whole stock, with the exception of 2025 stone, was sold, and that at advanced prices, varying from half a dollar to one dollar and a half additional per stone, according to the quality and condition of the wool. The prices obtained per stone were for

	Dollars.
Fine wools	21 to 24½
Middling fine ditto	18 „ 20
Ordinary ditto	16 „ 18

The clip was both better and more productive than that of last year. In some cases the washing and picking of the wool was found excellent, but there were many lots exceedingly defective in this respect. The wool of middling quality appeared to be in greater demand than the finer sorts, which indeed has been the case for several years past.

The *Breslau Wool Fair* on the 4th of June and following days is stated to have been numerously attended by purchasers from the manufacturing districts of Prussia and the Zollverein, as well as from Austria, France, England, Belgium, and Sweden. The demand in the month of May had been so great that the stock of Silesian wool in warehouse had been completely exhausted before the fair began, consequently the growers had made up their minds to a very large advance in price, which, however, was somewhat counteracted by the results of the last London sales of colonial wool, and by the inundations in France, which, it was thought, must endanger the harvest in that country, and consequently limit the French demand for wool during this summer. The growers therefore could not realize the advance of 20 per cent. which they had first tried to obtain, and the less so when it was found that the washing and picking of the new wool was decidedly inferior to that of last year. The rise in the price of good clean wools was, however, as much as from 8 to 12 dollars per centner. The deficiency of weight was generally about 10 per cent.

According to the official report of the Chamber of Commerce the quantities brought to this fair were—

	Centners.
Silesian wool	33,000
Posen ditto	5,000
Polish, Russian, and Austrian ditto, including the stock in warehouse	3,000
Total	41,000

* 1 stone of 22 lbs. = 22½ lbs. avoirdupois.
5 stones „ = 1 trade centner of 110 lbs. or 113 lbs. avoirdupois.
1 dollar of 30 groschen = 3*s.* sterling.

being 3000 centners less than the quantity brought to market last year. Above three-fourths of the whole quantity was sold; the proprietors of the rest preferred to borrow on a deposit of their produce, and to await the chance of a rise.

The following prices were realized per centner for the different wools sold, viz.:—

	Dollars.
Silesian electoral clip	138 to 155
Superfine clip	125 „ 135
Fine ditto	112 „ 120
Middling and middling fine ditto	98 „ 108
Inferior ditto	88 „ 93
One and two shearings rough	83 „ 86
Moist and tanners	74 „ 88
Posen fine clip	98 „ 108
Middling and middling fine ditto	85 „ 95

Further quantities of Polish wool were stated to be arriving at Breslau when the fair closed.

In order to facilitate the business of future fairs, and to prevent frauds, a permanent directory of seven merchants has been appointed at Breslau, who are to form a regular wool exchange, and control the brokers in the declaration of prices. The directory will also put itself in connection with the new Agricultural Bank, so as to enable the growers either to sell their produce promptly, or to obtain loans on deposit thereof, when the latter course may be preferred. These measures are likely to increase the attractions of Breslau as a central mart for Polish and Austrian, as well as Silesian wools.

The *Dresden Fair*, on the 11th of June, rather disappointed the expectations of the growers. The wool, however, was in very good condition, and an advance of from half a dollar to one dollar per stone was realized upon last year's prices. The whole stock brought to market was sold, being under 12,000 stone, or 2400 centners. Fine wools fetched from 20½ to 24 dollars per stone; middling fine wools from 17½ to 20 dollars per stone; ordinary wools from 15½ to 18 dollars per stone.

At the *Posen Fair* the washing of the wools was pronounced excellent, and the deficiency of weight was small. The prices obtained were various; all above those of last year, and in some cases an advance of from 5 to 10 dollars per centner. Many of the growers refused to sell, and reserved their wool for the Berlin fair. The quantity brought to market was about 6500 centners, including 1500 centners in warehouse from last year's stock.

At the *Gera Fair*, in the principality of Reuss, 7000 stone, or 1400 centners, were brought to market, being less by one-seventh than last year. Fine clothing wools fetched from 16 to 17¾ dollars,

and combing wools 16 dollars per stone, being, in both cases, an advance upon the prices of the last fair.

At *Landsberg*, on the Wartha, 8000 centners of wool were brought to market, which fetched higher prices by from 2 to 6 dollars per centner than last year. The washings were reported better than at Breslau.

The *Dessau Fair* was rather flat, inasmuch as of 5056 stone of wool brought to market, 2146 stone remained unsold. The washing was, however, very good, and the wool sold realized from 1½ to 2 dollars per stone more than last year.

At the fair of *Bautzen*, in Saxon Lusatia, 7698 stone of wool came to market, and 7006 were sold. The prices ranged per stone for

	Dollars.
Fine wools	19 to 21
Middling fine ditto	16 „ 19
Middling ditto	14 „ 16
Inferior ditto	12 „ 14

which average a dollar per stone higher than last year.

At the *Stettin Fair* 27,113 centners of wool were brought to market, or passed through, and nearly the whole stock was sold. Well washed lots fetched from 2 to 4 dollars per centner more than last year, and in some few instances from 6 to 8 dollars more, but a great deal of wool went at last year's prices. The highest price realized for superfine wool was 96 dollars per centner, fine fetched 81 to 92 dollars, middling and combing wools 72 to 78 dollars, inferior 50 to 72 dollars.

At the *Magdeburg Fair* only 2110 centners came to market. Prices rather lower than at Stettin. Washings very good.

The *Weimar Fair* was well attended, and of 38,500 stone of wool (7700 centners), nearly the whole was sold. The washings were good, in some instances excellent. Prices from 1 to 2 dollars per stone higher than those of last year.

The *Berlin Fair*, the largest of all the German wool fairs, took place on the 18th of June and following days. The quantity brought to market amounted to 104,000 centners, and there being in warehouse from last year 4000 centners, the entire stock was about 8000 centners greater than at the last fair. The weight of the fleeces was upon the whole greater than last year, but the washing, in many instances, was indifferent. The growers began by demanding an advance of 10 dollars per centner, but finding they could not obtain so much, they were obliged to be content with an advance of from 2 to 5 dollars upon last fair's prices. Wherever an advance of at least 2 dollars could not be obtained the reason lay in the bad washing of the wool.

The actual prices paid per centner ranged as follows:—

	Dollars.
Superfine wools, from	105 to 110
Fine ditto	93 „ 98
Middling fine ditto	82 „ 88
Middling ditto	74 „ 80
Inferior ditto	60 „ 70
Fleece and moist ditto	58 „ 70
Locks	55 „ 75

The purchasers were chiefly German manufacturers and dealers. The English customers were fewer than at last year's fair. The fair ended firmly, as it is called, that is, with the confidence that the present prices would be maintained for some time to come.

The continued rise in the price of wool is an indication of the activity of the German cloth manufactories, although these establishments are in so far unfavourably affected by the enhanced cost of their raw material. The English dealers have bought unusually little wool at these last fairs, for the rise within the last two years has much more than counteracted the reduction of the export duty from 6*s.* to 1*s.* per centner, which took place on the 1st of January, 1854.

Leipzig, June 30*th*, 1856.

IV.—*Use of Reaping-Machines.* By Anthony Hamond.

To the Chairman of the Journal Committee.

You ask me to give you my experience of the reaping-machine; I have great pleasure in doing so. I think I may fairly say that it has now attained that degree of perfection which entitles it to be classed amongst implements of real practical utility.

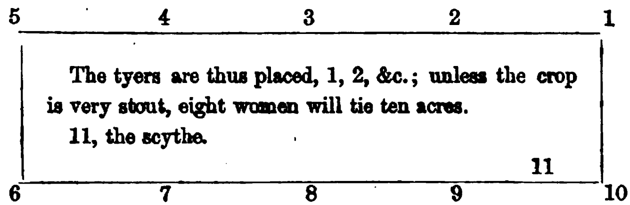
On the first introduction of the reaper to the notice of our Society, I purchased one by Hussey, which, being faulty in its construction, was soon laid aside.

At the Lincoln Meeting I purchased an improved Hussey by Dray, with tipping-board. This I have used for *two harvests* entirely to my satisfaction. It has not required 20*s.* in repairs, and is now ready to go to work at half an hour's notice. The first year I cut about 150 acres of wheat, oats, and rye; the second, 150 acres of wheat, besides oats and rye.

When I first used the reaper, I thought it expedient to divide a field into portions of about 10 acres, to facilitate the operation of tieing and shocking, but this I afterwards found unnecessary, the measure of work to be done being the *quantity cut*, not the distance travelled by the machine. The amount of a day's work by the reaper may be estimated at not less than 9 or 10 acres:

I have often exceeded 11. To accomplish this, from 8 to 10 women are required to tie and shock the corn, and one scythe (an inferior hand) to mow off the corners, which enables the reaper to continue its work without pulling up at the ends. The price of labour varies in different districts; with me, last year, the cost of cutting stood thus :—

	£.	s.	d.
The man who works the machine	0	5	0
The driver, a boy	0	2	0
An inferior hand, with scythe	0	2	6
Ten women, at 1s. 8*d*.	0	16	8



If a field from 2 to 3 furlongs in length, I should recommend 2 scythes; their work is not given away, as the reaper will do its 10 acres, and what these men will do will be in addition. Each scythe will tie up its own work.

It may appear that to tie an acre of wheat is a great day's work for a woman, especially as in mowing we allow 2 women to a scythe, but with a well-worked tipping-board the sheaves require no gathering, they only need binding, and they are laid so level that you have fewer sheaves to an acre than when mown. Be it also remembered that where there is no *gathering* there is little scattering, and scarcely anything for the horse-rake to do.

There is, I am aware, a strong feeling amongst some of those who take an active part in the implement department of the Royal Agricultural Society in favour of the side-delivery. For mowing corn that is to lie upon the swathe, it is absolutely necessary; but, for corn that is to be tied up, I prefer the back-delivery, for the reason I have given before—that where there is no gathering there is no scattering.

I hope to go to work next harvest with two Hussey's stern-deliveries and one Burgess and Key's side-delivery. The mowing of barley by the latter at Mr. Miles's, last year, was very near perfection.

NOTE.—I should strongly recommend all parties using reapers to have a spare set of knives ready for work; for should any accident happen, it is a serious business to have half a dozen hands standing still while damages are repairing. The bar, on which the knives are placed, is the only point where I have had a breakage.

Westacre, May, 1856.

V.—*Use of Reaping-Machines.* By THOMAS PARRINGTON.

Stanwick Park, near Darlington, Sept. 1855.

DEAR SIR,—Feeling sure that you will be pleased to learn that the reaping machine to which the first prize was awarded at Bristol, by the Royal Agricultural Society, fully bears out the high opinion entertained of it by many who witnessed the trials at Leigh Court, I have taken the liberty of forwarding to you the copy of a report given by Mr. Parrington of trials on his farm of Lazenby at Stockton-on-Tees. Every one who is acquainted with him will attach much importance to his opinion, in consequence of his great intelligence and practical experience in the use of reaping machines.

I remain, &c.,

James Hudson, Esq. JOHN WOOD.

Having had Messrs. Burgess and Key's McCormick's reaping machine at work on my farm for several days, and operating upon a variety of crops, I have much pleasure in expressing my entire satisfaction with its performances.

I have cut with it autumn and spring-sown wheat, varying in yield from 32 to 40 bushels per acre, some of it much lodged; also a very heavy crop of oats so much laid and twisted in parts, that I thought it impossible for any machine to cut them at all.

One pair of horses worked the machine easily day after day; they have to travel no faster than the ordinary ploughing pace, and a boy of fifteen managed them without any difficulty.

The machine is so constructed that there is very little wear and tear going on; it delivers the cut corn in a beautiful swathe, laid so straight and lightly on the ground that the sheaves are quickly gathered up—the swathe is evenly cut and left *particularly clean.*

I found that the machine will cut in the manner I have described from 1¼ to 1½ acres per hour; it is always cutting its full width, viz. 5 feet 8 inches.

I have had great experience in reaping by machinery, and I can honestly say that Messrs. Burgess and Key's machine is on the whole by far the most perfect and satisfactory implement I have seen.

Lazenby, Redcar, Sept., 1855.

VI.—*Experiments in Cattle-Feeding.* By E. W. Moore.

To the Editor of the Journal of the Royal Agricultural Society.

Sir,—Believing that it is the wish of the Council to make the Journal a record of facts which the experience of its members may enable them to furnish, I think that possibly you may consider the accompanying paper of sufficient interest for insertion in the forthcoming number. As you will perceive, it is the account of an experiment made in the feeding of animals of different breeds, and belonging to different owners. It arose in the following manner:—In the year 1853, two gentlemen (breeders of shorthorns) residing in this district entered into a sweepstakes of 5*l.* each to feed an ox from their respective herds for the purpose of testing their comparative merits in feeding for the butcher, and it was agreed that they should place their animals in the hands of some impartial person for the purpose. They requested me to undertake the matter for them, and, on mentioning the application to the Earl of Radnor, his Lordship was very willing that the experiment should be carried on here. From various causes the result was not satisfactory, and I made no award.

During the time this experiment was proceeding it occurred to me that it might be desirable to try one on a more extended scale between different breeds, and by a mode of feeding which would be more in accordance with the practice of farmers in their usual course of business than was adopted in this instance; I therefore wrote to several well-known breeders or their agents, who, at my request, sent animals of the ages and in the condition which appeared to me desirable. Eighteen animals were supplied—ten of one age and eight one year younger. The Tables herewith sent contain the result of the plan adopted. The animals in the first lot, as will be seen by the Table, differed a little in age, but not much in condition. A few days after they reached Coleshill, I requested Mr. Trinder of Moisey Hampton and Cricklade (a person who is in the habit of dealing extensively in cattle), to put a market price on each, which is the amount stated in the Table (with the exception of No. 1, where the amount actually paid was substituted). The only difficulty Mr. Trinder felt was about the Scot, which was very small, and the value of which was, I believe, finally fixed lower than he first thought of, in consequence of a remark made by myself.

The ten beasts were all sold by auction on the 4th of December, 1854, at Lord Radnor's annual sale of fat stock, no purchaser

that I am aware of having the slightest knowledge that any of the animals offered had been competing one against the other.

The second Table gives the account of the eight younger beasts, which were sold by auction on the 5th of February last. It is certainly unfortunate that there should have been so great a difference in the price of beef at the time these were sold from what it was when the previous lot was disposed of. Prior to the sale I had estimated the value of each beast, and had requested a neighbour, who is a good judge of such matters, also to examine the animals, and give me his opinion; and had they been sold at the same price per stone as the other lot, the result would have been very different from what it was in fact. I have added three columns as an appendix, showing what would have been the value of each animal at the rate per stone the others realized; and I have also entered the rate per stone they actually fetched according to my judgment as to weight. In looking carefully at the results of both experiments, I find it difficult to arrive at any very satisfactory conclusion; at the same time I think it proves this—that the Herefords take the lead in grazing. No. 7 in the first lot was decidedly inferior in quality to the other Herefords, which accounts for his not doing so well. The same difference in quality was remarkable in the Devons, and especially in the younger beasts. With reference to the shorthorns, Mr. Stratton's never did well; he told me at first that they were merely two ordinary animals from his general herd. The same remark applies to No. 18 in the second lot, which was a twin. No. 15, Mr. Bowly's shorthorn, did remarkably well throughout, and was of prime quality. No. 16 was a much coarser beast, and at last did not do well, though of immense size. The half-bred of Mr. Beasly's was wild and restless, and did badly, the latter part of the time especially, at which I was surprised, as a fellow-beast which Mr. Beasly fed himself turned out remarkably well; at one time during the first summer I thought he would have taken the lead. At the sale no one could get near to handle him, and I believe that made 2*l.* or 3*l.* difference in the price. It will be observed in the estimate made before the sale there is not so much difference between him and the rest.

My object, however, has been to record the facts, and persons interested in such matters must draw their own conclusions. No difference has been made in the rate per week charged against the last lot while at grass, except in No. 11, because the value of the food consumed by each in the house is nearly the same. They had what swedes or mangold wurzel and hay they would eat, and the same corn and cake, which they all consumed without any being weighed back.

Coleshill, May, 1856.

Experiment (No. 1) on the Feeding of

No.	Kind of Beast and Name of Owner.	Age, February 1st, 1854.	Kind of Food.	Total Quantity of Food eaten by each Animal, in the 4 Months, February, March, October, and November, 1854.				Price per Ton.		
				Tons.	cwts.	qrs.	lbs.	£.	s.	d.
1	Devon (Duke of Bedford).	1 year, 10 months.	Hay	0	13	3	10	3	0	0
			Roots	2	9	1	14	0	7	6
			Corn	0	1	3	14	12	0	0
			Cake	0	3	1	0	13	0	0
			Grass*	26 weeks at 4s. 9d. per week.						
2	Devon (Mr. G. Turner).	About 2 years.	Hay	0	13	3	7	3	0	0
			Roots	2	10	0	4	0	7	6
			Corn	0	1	3	14	12	0	0
			Cake	0	3	3	21	13	0	0
			Grass	26 weeks at 5s. 1¼d. per week.						
3	Devon (Mr. G. Turner).	1 year, 10 months, 10 days.	Hay	0	14	0	15	3	0	0
			Roots	2	8	2	22	0	7	6
			Corn	0	1	3	14	12	0	0
			Cake	0	3	3	3	13	0	0
			Grass	26 weeks at 5s. 1d. per week.						
4	Shorthorn (Mr. R. Stratton).	1 year, 10 months.	Hay	0	13	3	18	3	0	0
			Roots	2	15	2	7	0	7	6
			Corn	0	1	3	14	12	0	0
			Cake	0	3	3	21	13	0	0
			Grass	26 weeks at 5s. 2¼d. per week.						
5	Shorthorn (Mr. R. Stratton).	1 year, 9 months.	Hay	0	14	3	11	3	0	0
			Roots	2	15	3	19	0	7	6
			Corn	0	1	3	14	12	0	0
			Cake	0	3	3	21	13	0	0
			Grass	26 weeks at 5s. 4¼d. per week.						
6	Hereford (Duke of Bedford).	2 years, 5 weeks.	Hay	0	15	0	8	3	0	0
			Roots	2	16	0	25	0	7	6
			Corn	0	1	3	14	12	0	0
			Cake	0	3	3	3	13	0	0
			Grass	26 weeks at 5s. 3¼d. per week.						
7	Hereford (Duke of Bedford).	1 year, 10 months.	Hay	0	14	2	17	3	0	0
			Roots	2	14	3	24	0	7	6
			Corn	0	1	3	14	12	0	0
			Cake	0	3	3	18	13	0	0
			Grass	26 weeks at 5s. 3¼d. per week.						
8	Hereford (Earl of Radnor).	1 year, 6½ months.	Hay	0	13	1	3	3	0	0
			Roots	2	5	3	16	0	7	6
			Corn	0	1	3	0	12	0	0
			Cake	0	3	3	0	13	0	0
			Grass	26 weeks at 4s. 10¼d. per week.						
9	Hereford (Earl of Radnor).	1 year, 5½ months.	Hay	0	12	1	27	3	0	0
			Roots	2	3	3	15	0	7	6
			Corn	0	1	3	14	12	0	0
			Cake	0	3	3	21	13	0	0
			Grass	26 weeks at 4s. 10¾d. per week.						
10	Kyloe (Viscount Barrington).	About 2 years.	Hay	0	7	1	12	3	0	0
			Roots	1	16	1	8	0	7	6
			Corn		..			12	0	0
			Cake	0	2	3	3	13	0	0
			Grass	26 weeks at 3s. 6d. per week.						

* The beasts were all turned out and taken up together, and were at grass 26 weeks. The amount per week is fixed in the same relative proportion as the cost per week, during the four months they were in the house.

Cattle of different Breeds, 1854.

Value of each kind of Food.			Total cost of Food.			Money paid for each Beast.		Cost of Animal and Food.			Sold for (on Dec. 4, 1854).		Estimated Price per Stone.		Profit.			Loss.	
£.	s.	d.	£.	s.	d.	£.	s.	£.	s.	d.	£.	s.	s.	d.	£.	s.	d.	s.	d.
2	1	6																	
0	18	6																	
1	2	6	12	8	3	12	0	24	8	3	25	5	5	4	0	16	9	..	
2	2	3																	
6	3	6																	
2	1	5¼																	
0	18	9¼																	
1	2	6	13	7	1¾	10	15	24	2	1¾	26	10	5	4	2	7	10¼	..	
2	11	2¼																	
6	13	3																	
2	2	4¾																	
0	18	2½																	
1	2	6	13	4	4¼	11	0	24	4	4¼	26	10	5	4	2	5	7¾	..	
2	9	1																	
6	12	2																	
2	1	5½																	
1	0	10																	
1	2	6	13	11	11¼	13	0	26	11	11¼	26	5	4	10		..		6	11¼
2	11	2¼																	
6	15	11½																	
2	4	6½																	
1	0	11½																	
1	2	6	13	18	4¾	12	0	25	18	4¾	25	10	4	8		..		8	4¾
2	11	2¼																	
6	19	2½																	
2	5	2½																	
1	1	1																	
1	2	6	13	15	5½	14	0	27	15	5½	31	10	5	4	3	14	6½	..	
2	9	1																	
6	17	7																	
2	3	11½																	
1	0	7¼																	
1	2	6	13	15	5¾	12	15	26	10	5¾	28	0	5	0	1	9	6¼	..	
2	10	10																	
6	17	7																	
1	19	10																	
0	17	2½																	
1	1	0	12	13	6½	9	0	21	13	6½	24	0	5	4	2	6	5½	..	
2	8	9																	
6	6	9																	
1	17	5½																	
0	16	5½																	
1	2	6	12	14	10¾	8	0	20	14	10¾	23	10	5	4	2	15	1¼	..	
2	11	2¼																	
6	7	3½																	
1	2	0¾																	
0	13	7½																	
..			8	2	9	4	5	12	7	9	15	5	5	6	2	17	3	..	
1	16	1																	
4	11	0																	

Observations.—The animals were all in a store state at starting—they were fed as follows:—hay and roots, whatever they would eat. Anything given at a meal, and not wholly consumed, was weighed back and deducted. Corn and cake were given in the same quantities to all, and the same plan pursued as to what was not eaten within the usual time; the Kyloe would never eat any corn, and made little progress with cake in the spring. The price of hay and roots is fixed at the usual price of the neighbourhood; cake and corn at the market value.

Experiment (No. 2) on the Feeding of

No.	Kind of Beast and Name of Owner.	Date of Birth.	Kind of Food.	Total Quantity of Food consumed by each Animal in January, February, March, April, October, November, December, 1855, and January, 1856.				Price per Ton.			Value of each kind of Food.			Total cost of Food.		
				Tons.	cwts.	qrs.	lbs.	£.	s.	d.	£.	s.	d.	£.	s.	d.
11	Kyloe (Visct. Barrington).	Spring, 1852.	Hay	1	2	2	16	3	0	0	3	7	11	15	16	11
			Roots	4	3	2	15	0	7	6	1	11	6			
			Corn	0	3	3	9	12	0	0	2	6	0			
			Cake	0	3	1	7	13	0	0	2	3	0			
			Grass	At grass from Mar. 1, 1854, to Jan. 3, 1855, 44 weeks, at 1*s*. 6*d*. Ditto from May 1 to Oct. 14, 1855, 25 weeks, at 2*s*. 6*d*.							6	8	6			
12	Half-bred (Mr. J. Beasley).	Dec. 6, 1852.	Hay	1	10	1	18	3	0	0	4	14	4	18	11	10
			Roots	4	17	1	9	0	7	6	1	16	6			
			Corn	0	3	3	9	12	0	0	2	6	0			
			Cake	0	3	1	7	13	0	0	2	3	0			
			Grass	44 weeks at 1*s*. 9*d*., & 25 weeks at 3*s*.							7	12	0			
13	Devon (Duke of Bedford).	Feb. 21, 1853.	Hay	1	10	3	4	3	0	0	4	12	4	18	9	7
			Roots	4	16	3	4	0	7	6	1	16	3			
			Corn	0	3	3	9	12	0	0	2	6	0			
			Cake	0	3	1	7	13	0	0	2	3	0			
			Grass	44 weeks at 1*s*. 9*d*., & 25 weeks at 3*s*.							7	12	0			
14	Devon (Mr. T. Hole).	Feb. 2, 1853.	Hay	1	12	1	0	3	0	0	4	17	6	18	18	1
			Roots	5	0	1	8	0	7	6	1	17	7			
			Corn	0	3	3	9	12	0	0	2	6	0			
			Cake	0	3	1	7	13	0	0	2	3	0			
			Grass	44 weeks at 1*s*. 9*d*., & 25 weeks at 3*s*.							7	12	0			
15	Shorthorn (Mr. E. Bowley).	Feb. 9, 1853.	Hay	1	12	2	7	3	0	0	4	17	8	18	16	9
			Roots	5	1	2	7	0	7	6	1	18	1			
			Corn	0	3	3	9	12	0	0	2	6	0			
			Cake	0	3	3	7	13	0	0	2	3	0			
			Grass	44 weeks at 1*s*. 9*d*., & 25 weeks at 3*s*.							7	12	0			
16	Shorthorn (Mr. E. Bowley).	Feb. 9, 1853.	Hay	1	13	2	3	3	0	0	5	0	7	18	8	7
			Roots	3	12	0	15	0	7	6	1	7	0			
			Corn	0	3	3	9	12	0	0	2	6	0			
			Cake	0	3	1	7	13	0	0	2	3	0			
			Grass	44 weeks at 1*s*. 9*d*., & 25 weeks at 3*s*.							7	12	0			
17	Hereford (Earl of Radnor).	Jan. 18, 1853.	Hay	1	12	3	1	3	0	0	4	18	3	18	17	3
			Roots	5	1	2	24	0	7	6	1	18	11			
			Corn	0	3	3	9	12	0	0	2	6	0			
			Cake	0	3	1	7	13	0	0	2	3	0			
			Grass	44 weeks at 1*s*. 9*d*., & 25 weeks at 3*s*.							7	12	0			
18	Shorthorn (Earl of Radnor).	Apr. 5, 1853.	Hay	1	12	2	10	3	0	0	4	17	9	18	16	11
			Roots	5	1	3	20	0	7	6	1	18	2			
			Corn	0	3	3	9	12	0	0	2	6	0			
			Cake	0	3	1	7	13	0	0	2	3	0			
			Grass	44 weeks at 1*s*. 9*d*., & 25 weeks at 3*s*.							7	12	0			

Cattle of different Breeds, 1855 and 1856.

Money paid for each Beast.	Cost of Animal and Food.	Sold for (Feb. 5, 1856).	Profit.	Loss.	Price realized per Stone, according to estimated Weight.	APPENDIX.—Estimated result if they had realized the same Price per Stone, according to quality, as the First Lot. Estimated Value at	Profit.	Loss.
£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.	s. d.	£. s. d.	£. s. d.	s. d.
4 0 0	19 16 11	19 0 0	..	0 16 11	4 6	5s. 4d. per stone, 23 9 4	3 12 5	..
7 15 0	26 6 10	21 0 0	..	5 6 10	4 2	5s. 4d. per stone, 25 17 4	..	9 6
5 5 0	23 14 7	20 10 10	..	3 4 7	4 6	5s. 4d. per stone, 24 5 4	0 5 9	..
5 0 0	23 16 1	22 10 0	..	1 6 1	4 6	5s. 4d. per stone, 26 13 4	2 17 3	..
7 10 0	26 6 9	28 0 0	1 13 3	..	4 8	5s. 4d. per stone, 32 0 0	5 13 3	..
7 15 0	26 3 7	25 10 0	..	0 13 7	4 4	5s. per stone, 29 0 0	2 16 5	..
8 0 0	26 17 3	27 0 0	0 12 9	..	4 8	5s. 4d. per stone, 31 9 4	4 12 1	..
6 5 0	25 1 11	23 0 0	..	2 1 11	4 4	5s. 2d. per stone, 27 7 8	2 5 9	..

XI.—*Bringing Moorland into Cultivation.* By Robert Smith, Emmett's Grange, Exmoor.

Prize Essay.

The reclaiming of moorlands deserves attention among the other improvements of our native agriculture, as one means of providing food for an increasing population.

All lands as yet uncultivated or unreclaimed are properly termed the waste lands of England. They include several varieties of soil, and are placed at various elevations. They have (each in their way) some local and peculiar influences bearing upon their power of affording a due return for any spirited outlay advanced for their improvement. It admits of a question (which may fairly be discussed in the Journal of the Royal Agricultural Society) whether the modern improvements in practice or in science have advanced to such a degree as to give us any new advantages in grappling with those ancient difficulties which have caused certain moorlands to be hitherto neglected.

Some waste lands can only be turned to account by planting. Under this head fall those which are mountainous and rocky, or very much exposed; while the marshes, peat-mosses, bogs, and certain other moors, are more suitable for cultivation and improvement.

The difference between these two classes of waste land suggests a division of labour and risk in the task of improving them. It naturally devolves on the owner of an estate to retain the wild and unmanageable lands for the growth of timber, not only with a view to the picturesque beauty of an improving estate, but also as a means of lessening the disadvantages of an exposed situation, by providing shelter prospectively for the stock of future tenants, and further for use in fences, gates, and buildings. Where this first step is neglected a heavy loss is entailed on those who succeed to the ownership. On the other hand, such lands as will pay for cultivation should be intrusted to spirited tenants, with the encouragement of liberal covenants, suited to the particular district or occupation.

The term liberal covenants may suggest innumerable and vague ideas as to the development of enterprise. But it is evident that for such a bold and important enterprise as the "reclaiming of waste lands," hitherto untouched by the hand of the husbandman, extraordinary encouragement in some form either is or ought to be given by the landlord. This encouragement may be given by low rents, long leases, or by pecuniary assistance, which is, in fact, the loan of capital. It is the opinion of the writer that, with a view to stability and an honest and

mutual interest in the future welfare of an estate, far the best plan is that the owner should advance at once, and meet the outlay in *permanent* improvements, by the expenditure of his own capital, as an investment, with a view to enhance the value of the "fee simple" of his property. When the owner of moorland is so circumstanced that he cannot with justice to his family sink capital in an estate in which he may have only a life interest, his operations will be greatly facilitated by applying to some of the companies recently formed for the improvement of lands.

The permanent improvements in buildings, fences, roads, &c., having been provided by the landlord, there follows a suitable rental and the full use of a tenant's capital in cultivation, tillages, and tenant's works. Otherwise, when a tenant's capital has been too freely invested, under sanguine expectations, in making permanent (or landlord's) improvements, disappointment frequently ensues; further, the delusive prospects of profit from permanent improvements performed and paid for by the tenant have an unhappy tendency to produce discontent, and ultimately discourage other tenants from similar enterprises. This distinction in the employment of the two capitals should not be lightly overlooked, or treated as a passing remark; for upon a proper adjustment of the several outlays and interests mainly depends the success of the undertaking.

Moorlands are of various descriptions. They are sometimes situated in low and comparatively mild districts, sometimes on moderately elevated lands, but more commonly upon the higher ranges of hill or mountain. The former, from their low range of altitude, are usually within the reach of common cultivation, but much depends upon their geological formation, subsoil, and on the proximity of manure and markets.

Our principal attention will be given to the elevated moors as presenting greater difficulties. This part of the subject will be the more interesting and practically useful in the present state of agriculture.

Moors much elevated above the sea, or where the surface is covered with stones, heather, or rough grasses, are seldom worth the expense of cultivation, and from their height and consequent exposure are best adapted to woodlands and wild mountain pasturage for a hardy race of animals. These lands are usually covered with indigenous plants, which should be observed. Where the fern, broom, or heather grows, the turnip may with safety be cultivated, while the presence of the English furze or whin too frequently indicates a cold, poor soil; in this case the habit and growth of the plants should be closely looked to, as they clearly indicate the particular nature of the soil, and show

how far it may be trusted to produce roots and artificial grasses with advantage, in return for the expenditure of capital.

It is a practical truth, and worthy of attention, that a very large proportion of the best arable lands now under modern or first-class culture were originally (and in many instances not long since) covered by indigenous plants; but while so much has been reclaimed from time to time in the more favoured altitudes, the *great work* of reclaiming the "real moors" yet remains to be done. The Lincoln heath and fens were brought into their present condition as arable land by the hope of a return from corn crops; large quantities of oil-cake are annually consumed on soils naturally poor solely with a view to corn. The moors which will form the chief subject of the present paper are situated at too great an elevation for the growth of grain crops with profit, and have thus as yet not commanded sufficient attention. But concurrently with an annually increasing importation from abroad of the various breadstuffs, it is evident that the increasing consumption of food by a population becoming every year more dense, upon a fixed area, must ultimately bring many high lands, hitherto neglected, into notice for the production of stock.

Farms already in cultivation, on which the growth of corn and the feeding of stock may be combined, having "the call" for occupation, the moorlands have usually either been left to men of small capital, or have been treated as adjuncts to other occupations, and even on this plan have done wonders.

In connexion with the moors of inferior order, we have in Great Britain far too large a proportion of peaty lands, mosses, bogs, and even morasses; but if we turn to the sister isle, Ireland, we find it stated that at least 1,500,000 acres are covered with "flat red bog," in addition to peat soils covering mountains, capable of being improved for *pasture* or plantations, to the extent of 1,250,000 acres, making together nearly 3,000,000 of acres. To deal with this class of lands long and even sedulous attention must have been paid by the improver before he risks too lavish a hand in the reclaiming of these usually deep and hazardous lands.

In speaking of "peaty soils" there are those of moderate thickness or depth in the English counties that have been occasioned by stagnant waters previous to their subsequent drainage, such as the peats of Yorkshire, Lincoln, Cambridge, Huntingdon, Lancashire, &c.; and if evidence of improvement was necessary, we have only to point to these lands, which *now* yield abundant crops of every description of grain and vegetables, so that they may be ranked in the first class of corn-growing districts. On the other hand, the marshlands of England, producing the

better grasses alone, have long been redeemed from their wild and boggy state by suitable drainage and other improvements.

The fresh-water marshes were once closely allied to the present unreclaimed moorlands in their production and reception of redundant water and springs; but by being interspersed with arable land they have been more quickly and profitably improved, partly by necessity, and partly owing to other and valuable precedents on adjoining or neighbouring estates.

The valuable marshes on the eastern plane of England, Romney marsh in Kent, the Somerset marshes, &c., fully illustrate the immense return resulting from former improvements in their redemption, as they are now employed in the production of permanent feeding grasses for cattle or the scythe. Even the downs and other *dry* open lands, treated as "sheep-walks," have of late been much trenched upon by the neighbouring farmers for the use of, and addition to, their present arable farms. These downs in the south of England are usually so thin of soil that they afford but little temptation to the husbandman, and are thus used as "open downs," affording a run for the breeding flocks of the several farms, or for the support of what is called a "working flock" of sheep, intended to act as manure-carriers, browsing by day, and closely folded by night on the corn-land. The knowledge of the true elements of manure gained by the aid of chemistry is introducing a better system, though folding may always retain its proper mechanical use.*

The waste lands in Yorkshire and Lincolnshire are provincially termed "the Wolds."† The soils of these districts vary much; but from their favourable position in reference to climate and to markets they have been for the most part brought into cultivation. There yet remain sandy soils stocked with rabbits; but, I judge, these are indeed of moderate worth, and have shown little signs of response to outlay; otherwise the marked improvements which have followed upon claying and marling must have told upon the owner and occupier. For we have recorded facts of improvements upon *this* class of soil by reference to the Norfolk estates, raised up from barren sandy wastes to rich and fertile fields, producing alike every variety of produce from "horn to corn," and these of the *very best* quality. Consolidating substances, such as marl, the feeding of green crops by sheep, folding, &c., have gone far to produce these valuable results upon thin sandy soils.

* Much still remains to be done on the marshes in the levels between the Mendip and Quantock Hills. Unfortunately the agricultural remedy cannot be applied until some comprehensive legislation shall compel the subordination of jarring private interests to public good.—T. D. A.

† The term "Wolds" is in Yorkshire exclusively applied to the chalk hills in the East Riding.—H. S. T.

Before embarking in extensive improvements upon any available waste lands, however inviting, it is prudent to assume that these have some peculiar or local disadvantages, or they could not have remained as "waste lands" during so long and interesting a period of our modern husbandry; and even if the neglect of these lands be owing to prejudice, it is well to satisfy oneself distinctly on what the prejudice rests, for it is sure to have some foundation—whether a sound one or not may be ascertained by careful inquiry, or at least by prudent experiment. Again, if the native farmers are shy to encounter them, it is doubly important for a stranger to meditate well upon this, and to calculate carefully the intended outlay, and not less carefully the probable return, after allowing a wide margin for losses by bad seasons and accidents.

The groundwork of improvement upon which a practical man may go with safety is first an accurate knowledge of the district, its advantages and disadvantages, its roads and markets, together with a faithful estimate of the present and probable future value of the lands to be reclaimed. If an extensive improvement by enclosure and subsequent culture is intended, a general map of the district or lands should be made, and an actual survey made of all springs, bogs, watercourses, wet or dry lands, hilly or flat. This should be committed to paper for future reference and guidance in the adjustment or laying out of intended farmeries. On the same plan all mines, quarries, ancient roads, natural woods, rights of streams or springs for irrigation, should be accurately and historically marked.

In carrying out extensive works it may be required to improve the outline or general consolidation of an estate by purchase, sale, exchange, or otherwise, in order to secure outlets for drainage, connecting roads with villages, highways, &c. Much of the ultimate value of an estate depends upon these connecting links, or on the natural facilities for improving them. Attention should also be paid to outstanding common rights and claims, which are sometimes not clearly made out till the increasing value of adjacent land makes them more difficult to deal with. The work then proceeds satisfactorily upon a prepared system and plan, which may at once be turned to in the office when questions arise as to new occupations.

In proceeding to the practical discussion of the best methods of "bringing moorland into cultivation," it will simplify the subject to take them in regular order, commencing with the wild and open moorland "as nature formed it."

The Effect of Climate.—Open wastes at an altitude of 700 to 800 feet and upwards are beyond the growth of wheat or barley, with profit, except in a few situations exceptional for aspect or shelter and consequent warmth. In some dry seasons a tolerable

return may be made; but in backward seasons the produce at this height, owing to exposure to the moist vapour, is of small value. Even in average seasons these crops too frequently outgrow their strength (from the humidity of the summer), become lodged at an early period, and consequently are of little use beyond the abundant supply of long coarse straw.

Not only the latitude and elevation of a country above the sea are important, but the aspect and vicinity of lands to mountains, or to swampy ground, are also material in their influences on temperature and natural growth. Again, the prevailing direction of the winds, the length of time the sun continues above the local horizon, the difference of temperature between day and night, as also the extent of dry surface in the neighbourhood, are each in their way balancing elements and powers for and against the climate of every district, but more especially those under present consideration.

The value of a high or medium range of temperature is marked by its effect upon vegetation, as at a certain degree of heat, say 40°, many plants become torpid, and remain in that state until a higher range of the thermometer takes place. When revived by the warmth of spring, and strengthened by the summer's sun, they acquire fresh life, vigour, and maturity. The average heat of a season is not so important as its intensity and continuance at a certain height while the crops are ripening; it is the absence of sun, and the low range of temperature, upon elevated lands, that prevents the growth of cereal crops with advantage, but more especially the growth of the wheat-plant, which requires a much higher range of heat than barley, while oats may be grown as "weeds of the country" in most elevated situations, though, of course, their profitable result will depend on the season and the harvest.

The winds that prevail in any particular quarter have a greater influence on the character of a climate than is usually supposed; and truly is it said that "the wind rules the weather." For instance, the winds that have passed over from the coldest regions of Europe, and on to our island, are comparatively colder than those that blow over the Atlantic ocean. The former are very properly designated the cold, dry, easterly winds, while the latter are usually laden with vapour, and often contain such an excess of moisture as to be even prejudicial to a whole neighbourhood, but more especially the *elevated* districts.

Evaporation is again an important and objectionable circumstance in a moorland district, which can only be cured by the suitable drainage of its springs and surface waters.

Arrangement of Moorland Farms.—In the laying out of a hill farm which shall be chiefly dependent upon its own re-

sources, it is found best (after suitable plans and arrangements have been agreed upon for the sites of plantations and public roads) to divide the lands into three distinct classes.

First, the hill-top and other rough land should be set out (if possible) in one block as summering ground for young cattle, store sheep, colts, ponies, &c., to be subsequently improved by "surface drainage," similar to the Scotch plan of "sheep-drains"—an inexpensive process, yet found of infinite value. Upwards of one hundred pounds have been expended in this process, near to my residence, by one of the tenants; and I can thus speak with accuracy as to the value of these drains.

The second or middle class of land to be set out is the portion lying immediately below the rough wet ground, or situated upon a southern aspect; this is usually dry, healthy ground; these lands are intended for arable culture.

The third class consists of the flats and marshes in the valleys, together with some portions of the adjacent hill-sides, which should be laid out for pasture and water-meadows. The practical bearing of such an occupation is that of *stock-producing* returns, consequently an eye must ever be had to this particular class of farming.

In the arrangement of the farmstead care must be taken to so place the buildings that "water-power" (in a hilly, moist country) may contribute its full share in the works to be taken in hand. To the water-wheel we must look for the future economy of the labour at the yard. It will perform the thrashing, chaff-cutting, grinding, root-slicing, &c.; the stream may also be so arranged as to wash all roots, cleanse all offices, collect the sewage of the establishment, and finally convey the refuse to the adjacent meadow below the farmstead, and so on to the end of the farm or meadows. But this cheap and inviting aid must not carry the improver beyond the proper requirements of a "hill farmyard." It must ever be remembered that we are treating of stock-farming, and not of the harvesting or thrashing of corn, as our pursuit; neither will it be wise upon a small farm to concentrate too many sheds at the farmstead, as they will be more appropriately situated if placed near the several watered meadows, there to consume the hay, and produce manure upon the spot for future improvement, and thus save lots of cartage of both hay and manure. Suitable water-gutters should be provided to convey all liquids, &c., from these sheds to the adjacent meadows below.

The carriage of root-crops to a farmyard in a hilly country is objectionable, and should be reduced to the lowest possible point; the consumption of roots with straw, &c., in yards does not belong to a hill farm; it is far better to avoid growing the straw,

keep but little cattle in the winter, and to eat the roots upon the land with sheep as a general rule.

In laying out the fields, paddocks of say 4 acres each should adjoin the homestead as nearly as possible; then should follow a range of fields about double in size, say 8 acres. As the fields gradually become more distant from the buildings they may be increased in size, according to the position of the lands for shelter or other local circumstances; but these (if possible) should not exceed 12 acres. On farms of considerable size, and where the object is (very properly) to keep a large flock of breeding sheep, fields of much larger dimensions may be laid out; but let these be the more distant ones for general pasturage.

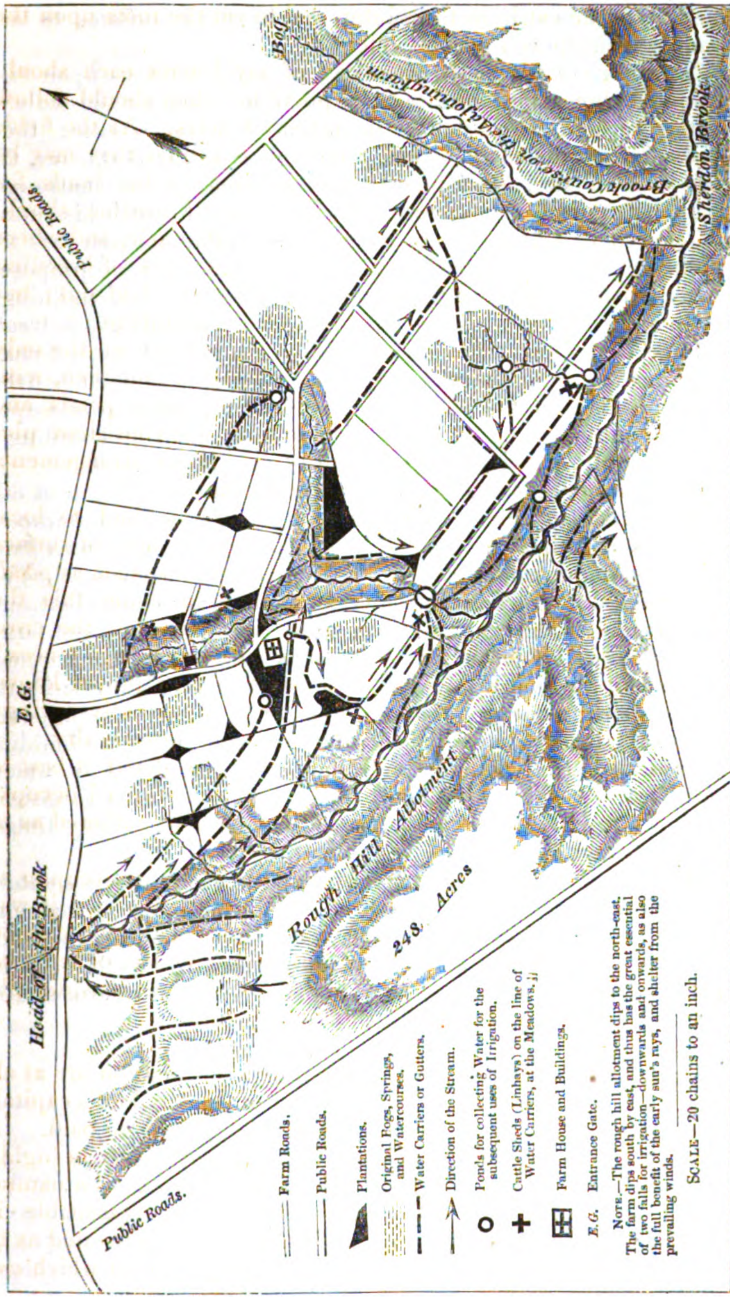
In making these arrangements the better, and indeed the only proper way, is to commit the lands to paper, and then, with "plan in hand," all buildings, sheds, fields, roads, ponds, and watercourses, may be so adjusted as to form one consistent picture of convenience, and to simplify the future arrangements whether arable, grazing, mowing, or manuring.

In setting out these fields an eye should be had to local facilities as well as to general rules: the conveyance of surface water by means of the fence sides to given points, such as *ponds* for irrigation, gives an instance in point; in doing this the "spirit-level" may be advantageously used, so that the cross fences upon a hill-slope may be used as "water-carriage fences." But the first essential in a hilly district is to get a proper knowledge of the lands to be *drained*, as many apparently springy lands only require to be subsoiled to lay them perfectly dry.

Since writing the above outline I have considered it best to illustrate the subject with a map of the farm which I occupy, from a reference to which a general idea may be gathered as to the plans just described.

The hill-farm referred to was taken in hand by its occupier as nature formed it in the spring of 1848; at that period it was wont to produce the aquatics and heather plants, to the exclusion of better pasture, but it now exhibits every variety of artificial grasses, valuable roots, watered meadows, and a considerable flock of breeding ewes, cattle, colts, and ponies.

Buildings.—The BUILDINGS upon a new occupation are at all times an important feature in the outlay of the landlord's capital, and upon such outlay a proper percentage should be paid. If, when landlords hesitate to advance these improvements in highly cultivated or favoured districts, they can only expect as a natural result an indifferent tenant, how much more reasonable is apathy on the part of the tenant of lands yet uncultivated as to his own experimental outlay with a view to a return which can


Bog
Public Roads.
Brook Course on the adjoining farm
Sherdon Brook
E.G.
Head of the Brook
Rough Hill Allotment
248 Acres
Public Roads.
Farm Roads.
Public Roads.
Plantations.
Original Fogs, Springs, and Watercourses.
Water Carriers or Gutters.
Direction of the Stream.
Ponds for collecting Water for the subsequent uses of Irrigation.
Cattle Sheds (Linhays) on the line of Water Carriers, at the Meadows.
Farm House and Buildings.
E.G. Entrance Gate.
NOTE.—The rough hill allotment dips to the north-east. The farm dips south by east, and thus has the great essential of two falls for irrigation—downwards and onwards, as also the full benefit of the early sun's rays, and shelter from the prevailing winds.
SCALE—20 chains to an inch.

at best only be conjectural, when the landlord hesitates to take his share of the venture!

To simplify and economise the outlay in buildings upon hill-farms, I have found it a good plan to build at a fixed scale of outlay, according to acreage. Let us suppose a case: thus, should an application be made for a farm of say 300 acres, the party is naturally ready to name his (already selected) spot "upon the open moors," and the whereabouts to pitch his future home; these conversations over, and a guarantee given that the party applying has sufficient five-pound notes for the proposed undertaking on his part, the number or amount of buildings, style of residence, &c., next forms a leading subject of the treaty "to be or not to be." The printing of a general lease, tenant-right compensation, memorandum, &c., is a small matter to overcome; and it is the want of some fixed basis to negotiate upon for the buildings, which has led me to the plan of spending a *fixed* amount of capital per acre in the erection of them.

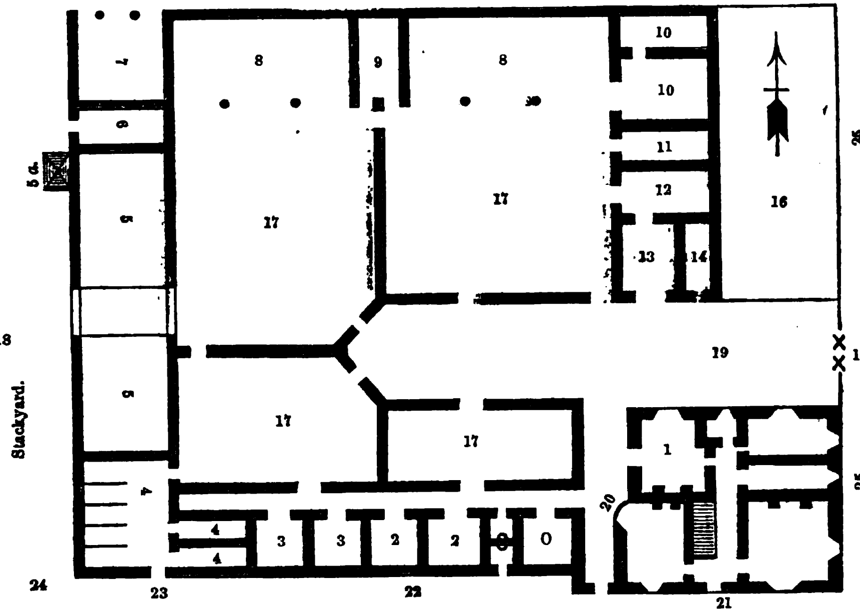
A tenant who proposes to rent and cultivate a farm of 300 acres of rough hill land is usually a man of the neighbourhood, who has a heart for "roughing it," and can turn his own hand to the plough when wanted. This tenant at once disclaims all idea of a smart house, but asks for small yet convenient out-buildings. Assuming that, upon an average of cases, these farms are to have one-fourth of their lands lying waste for summer pasturage, two-fourths or half the farm as arable, and one-fourth as meadow, an outlay of two guineas per acre upon the proposed improved occupation will be ample for every requisite building both at the farmstead and for cattle-sheds (linhays) at the water-meadows. As a confirmation, I supply a plan of a farmstead with its actual cost of erection, as also one of a cheap linhay (open cattle-shed).

By this plan every facility is afforded to the farmer for watching his farmyard occupations from his sitting-room or bedroom windows, the use of water-power, and every other requisite for his farm. This plan may be adapted for yearly outlays, to be spread over say four years, as per plan given for a farm of 100 acres and upwards at page 361.

PLAN OF BUILDINGS.

Size of Farm 300 Acres (in a hill country).

SCALE—32nd part of an inch to a foot.



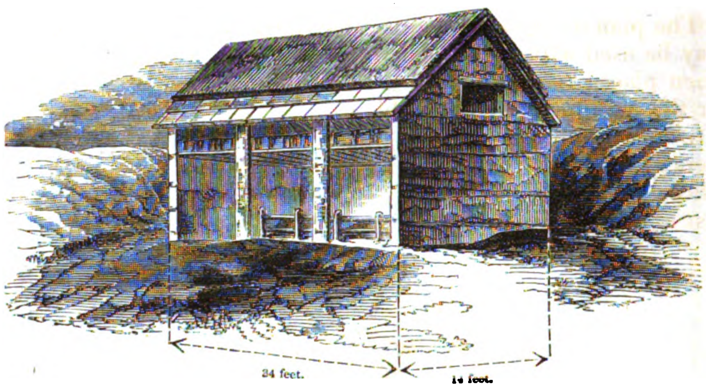
1. Farm-house. O. Ash-house. ⊕. Privies.
2. Calf-houses.
3. Piggeries.
4. Cart-horse stable, chaff and gear houses, with granary over for hay and straw, cutting chaff, &c., with door out of stack-yard and barn, with spout to convey the chaff to the house below.
5. Barn, with water-power attached.
5a. Water-wheel.
6. Implement-house. } Granary over out of the barn, and
7. Cart-shed. } load the corn underneath.
8. Open or close cattle-sheds.
9. Turnip-house.
10. Cow-sheds.
11. Loose box.
12. Nag-stable.
13. Gig and harness house.
14. Coal and wood house.
15. Entrance gates.
16. Kitchen-garden.
17. Open yards, for cattle, horses, or pigs.
18. Stack-yard.
19. Entrance paved road to all the yards separately.
20. Sitting-room window, which commands every door, office, and yard in the interior of the buildings.
21. Front entrance and garden.
22. Shrubs.
23. Entrance to the cart-horse stable.
24 and 25. Planted.

COST OF ERECTION IN 1850.

			£.	s.	d.	TOTAL. £.	s.	d.
South Front....	Total cost of	building farm-house	146	13	10	177	9	2
,,	,,	carriage of materials	30	15	4			
,,	,,	building calves' houses and piggeries, &c.	36	2	8	46	13	4
,,	,,	carriage of materials	10	10	8			
West Side......	,,	building barn, stable, and cart-shed	128	9	6	160	15	3
,,	,,	carriage of materials	32	5	9			
North Side......	,,	building open cattle-sheds and turnip-house	39	16	8	50	8	4
,,	,,	carriage of materials	10	11	8			
East Side.......	,,	building cow-sheds, stable, box, gig and coal houses	47	4	4	58	15	0
,,	,,	carriage of materials	11	10	8			
Farmyards	,,	building stone-walls, gates, &c.	14	9	4	18	13	4
,,	,,	carriage of materials	4	4	0			
						512	14	5
		By increased cost in 1856—say 17 per cent.				87	5	7
						£ 600	0	0

PLAN OF LINHAY (Cattle-Shed),

For the Water-Meadows.



The above linhay is 30 feet long by 10 feet in the clear, with two oak posts or pillars, and hay-loft over, and is placed against a hill-side fronting the south; thus, in cutting out the site in the hill-side to place the building, sufficient stone is taken out for the walling.

Total Cost.

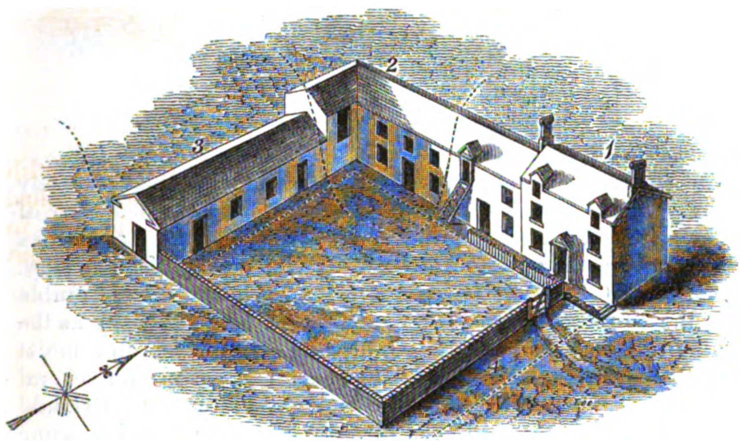
	£.	*s.*	*d.*
Walling, 34 perch, at 1*s.*	1	14	0
Raising stones for ditto, at 1*s.*	1	14	0
Woodwork, roofing, &c.	1	0	0
6 square of thatching, at 12*s.*	3	15	0
Slating roof, at 6*s.*	0	9	0
	8	12	0

The wood is found gratis by the estate. It is usual to enclose a suitable yard in front, with drains to carry away the soil to an adjacent pond, or empty at once into a passing water-carrier (at the foot of the yard), to be shed over the meadows below; but this is an arrangement that can wait its time. This shed will hold from eight to ten head of cattle, according to their size.

The scale of figures given for the farmstead and linhay (at per acre) will be found to fully cover every requisite erection, and may be applied to farms of any size; for instance, suppose a tenant with small means, but full of energy, who has a growing industrious family about him, applies for a "small farm:" his case may at once be met by the proposal to expend 2*l.* per acre upon his farm of say 70 acres (three-fourths of which is improvable); and then, should his industry lead him to a further application for additional land, up go a corresponding amount of buildings.

In the case of laying out small farms especial care must be taken so to arrange the buildings that they may be "added to" from time to time to the extent of any probable increase of land that may be thrown into the farm.

The plan of "granary-barns," hay-lofts, &c., in a hilly country may be used with great advantage, and with a saving of capital when placed against hill-sides. In this case the hill is cut away for the buildings, and a suitable road is formed at the back upon a level with the granary or granary-barn floor—a great convenience in practice, the chief merit being that of having two offices under one roof; the roof being the major outlay in the cost of all buildings.



Isometrical View of House and Buildings for a Farm of 100 acres and upwards, if required.

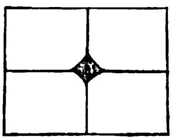
The above plan is arranged to suit the outlay upon a small farm, so that the buildings may be erected from time to time as the tenant requires them for use, and as the receipt of rent comes in to assist the landlord's outlay. Thus in the outset, and during the first summer, the house and adjoining offices, stable, &c., with granary over (1), may be erected, and the square yard enclosed by a substantial wall, which will come into use when the subsequent buildings shall have been erected. Second year, the remaining south offices, stables, &c., with granary over, and granary-barn with sheds under (situated at the north-western wing), may be erected (2). Third year, the western cattle-sheds, turnip-house, &c. (3). Fourth year, the eastern side may be filled up or not, according to the progress of the farm.

The usual estimate for this class of buildings, 12 feet in the clear, of proportionate height in the walls, roofing, &c., and

adapted to the usual average purposes of this class of farm, is about twenty-three shillings per running foot.

Should men of capital and enterprise wish to try their hand at extensive enclosures, cultivation, stock-farming, &c., even *then* the house and buildings can be erected to suit them, at the same rate of outlay, and on the same plan of divisional erection.

Fencing.—Good fences are of course an indispensable requisite in the enclosure of unreclaimed land. Fences are not only necessary to protect crops, but contribute in no small degree, by the shelter they afford, to augment and improve the produce itself. The making of small plantations upon a farm, or the planting of corners between fields, thus,



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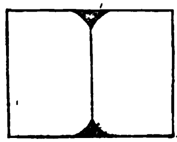


are good adjuncts for shelter.

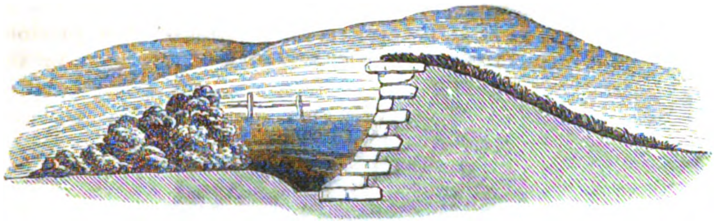
The disposition and situation of fences depend upon a variety of circumstances, such as the extent of the farm, the character of the land, whether arable, pasture, or meadow, on the inequalities of the surface, the supply of water, and the course of husbandry. On farms of tolerable size, having a moderate quantity of arable land, the number of enclosures should be twice as many as the number of years in the rotation of cropping. Thus in a moist grass-land district, where the fields remain in pasture for several years, and are under the six-field course of culture, there should be twelve enclosures, two of which are always under the same crop; and the situation of each field should be so arranged as to group together a good and an inferior field, one being at a higher elevation than the other, and consequently at a greater distance from the homestead—the homeward field (being nearest the manure heap) thereby affords roots for the yards, if wished, while the distant, elevated, poorer field has its produce consumed upon the land.

In the adjustment of the lines of fences much convenience and some saving of expense in drainage will be secured if they are made to correspond with the outlets of the main drains, and these again with the carriers for irrigation.

The boundary fences formerly erected in hilly districts against the open common lands are termed "one-sided fences," from the circumstance of their being made with an upright facing on the outer side, and a moderate slope on the inside. This fence is faced with stones.

The front of this fence is first sunk to the depth of 2 feet, and

the soil thrown upwards to raise the head or intended bank. The stone ditching of the front, by layers of stone placed edgeways, then proceeds to the height of 5 feet, when previously selected rough stones are placed upon the head, as a coping or chief protecting stone to the whole fence. Thus completed, the fence is full 6 feet high, and proves a formidable barrier against all intruders; but this style of fence is never better than when first erected.



Its not being planted or raised on the inside is objectionable,—as sheep especially, can readily jump down, but not in again,—and must have been adopted, as a present saving of outlay, in former times; they are rarely used at the present time; I have had invariably to "double them up" on the inside when laying out new lands for cultivation. Tenants will not accept them as boundary fences.

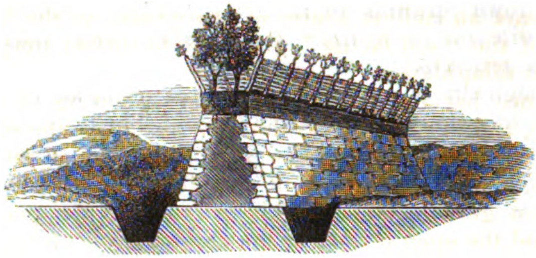
This fence, when completed, costs per perch of 16½ feet, for—

	s.	d.
Casting the bank	1	3
Quarrying the stones	1	3
Carting the stones, upon an average of half a mile	1	3
Building the face wall	1	3
	5	0

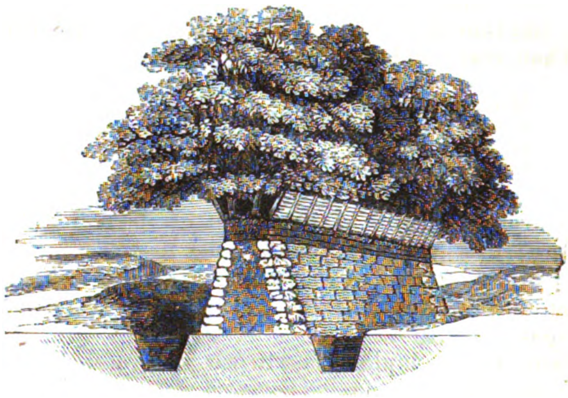
The more modern fence, both for boundaries and substantial subdivisions, is faced with stones on each side to the height of 4 feet, and then headed or finished with 2 feet of grass sods, making the fence when completed full 6 feet high. These fences are then planted with beech-plants in two rows upon the crown of the bank, and are protected by low hedges on each side, the stakes of which are made from fresh-cut live willows, and the hedging wood is from the nearest coppice of the neighbourhood.

The plan of live stakes (provincially termed withy pitches) is a good one. The withy-plants and hedging materially aid the growth of the beech-plants, and support the bank by the quick growth of their roots.

The cost of this style of fence is heavy, but it is a good and permanent fence when once erected.



This fence should be completed by the end of February
The sketch shows the first year's growth.



Fence when grown to its best, before being layed or touched in any way.

I give the cost of this fence entire, at per perch :—

	s.	d.
Throwing and heading the bank	1	6
Building 4 feet of stone on each side	1	6
Quarrying the stones for ditto	1	6
Carriage of stones, upon an average	1	6
45 beech-plants	0	8
Planting beech-plants	0	1
22 withy pitches	0	9
Hedging wood from coppice and carriage	1	1½
Hedging both sides of fence	0	3
	8	10½

In the erection of new subdivision fences it is usual for the tenant to do the carriage at least, but these are matters of purely local arrangement according to mutual agreement.

There is another style of bank, "the sod-bank," which is the more common one, from the *apparent* cheapness of outlay in the first outset. This fence, from the nature of its composition, being made entirely of soil and *native* grass sod facings, proves

in after years an endless source of annoyance, as the least disturbance of the "sod facing" gives rise to further trespass, and consequent dilapidation.

This fence has the same heading and planting as the last-named one, and in formation is the same as to size, the sods being substituted at the side facings for stone, as shown in the preceding sketch. The misfortune of this fence is, that the native sods do not grow together. This arises from the poorness of the soil and the open texture of the natural earth under its thick covering of indigenous plants.

When new fences of this order are erected upon old improved lands, the sods are of much better quality as to solidity and goodness, and thus unite by future growth, and form a tolerable fence. Their cost stands thus:—

	s.	*d.*
Making the entire bank	2	0
Beech-plants and planting	0	9
Materials, hedging, &c., and carriage ..	1	4½
22 withy pitches	0	9
	4	10½

As time goes on, these banks require to be faced with stone to the height of 4 feet; this, with certain repairs consequent upon the former, amounts to about 4*s.* 6*d.* to 5*s.* per perch, including the carriage.

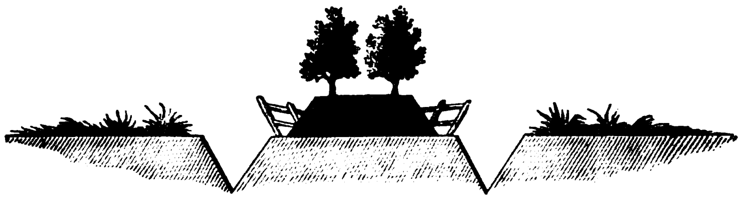
By sinking the ditch at the foot of a bank, in a *triangular* form, say 2 feet deep, all cattle, &c., are prevented reaching the growing plants, or otherwise injuring the bank by their feet. This is indeed a valuable preventive.

Upon moorlands that have those unfortunate clays for their surface and subsoil, it is not uncommon to see a double sod fence thrown up, with deep ditches on either side, and three rows of quick planted in the centre, one on each side and one in the middle. This fence has many objections, but none greater than the enormous extent of land it occupies.

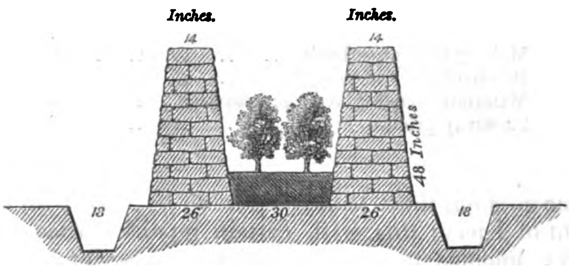
The merit of lofty bank fences (especially when they have their growing wood upon the top) is in the immediate shelter they afford in an open, bleak, and elevated district; and are thus very properly termed and used as *the* fence of the country on open moorlands.

In the enclosure of moderately elevated moorlands many have had recourse to what are termed "hedges upon the flat." These have a ditch sunk upon each side, and the soil extracted is thrown into the centre, whereby a raised platform is made, and the quick-plants laid in as the works proceed, or at its earliest completion, taking care that the roots are deposited in the *best* soil; when they are thus advanced, an additional "back fence" by a

double post and rail, placed upon the inner side of the ditch, for the protection of the plants, is given thus :—



At the period of the Lincoln Heath enclosures, it was customary to adopt the plan of double sod-banks on either side, and a double row of quick was planted between them.



These banks were composed of native sods, and built up one upon the other, as shown in the sketch, similar to dry stone walls, the base of the bank being wide, and then gradually tapering to the top.

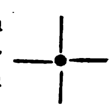
So soon as the quick became of sufficient consequence to form a fence, these decayed banks were mixed with lime, and applied to the land as manuring substances.

The stone wall fence is a great favourite on the Heath ; and as the stones are upon the spot, many miles of it have been erected, and stand good to this day.

The objection to this stone fence is that it never improves itself or the scenery around, and has a cold appearance.

The number of fences upon a farm will entirely depend upon the amount of shelter (or succour, as the west-country farmers call it) required by the situation and climate.

The plan of cross banks for shelter, thus, as used in some parts of Scotland, are valuable aids for sheep-farming in stormy weather. They should be placed in good and selected situations.



Having myself occupied rather largely both in the east and west of England, I can bear full testimony to this remark, and I cannot but think that the " sweeping remarks " which are levelled

at the west of England fences, although they may have been well intentioned, are wrong in the main. We must not forget the Atlantic gales.

In corn countries it is no matter how few and how low the fences are, but in a moist, windy, and elevated district, suitable for the production of stock alone, which naturally requires shelter against such elements, good stoned and ditched banks, with healthy beech-plants upon them, are no small adjunct to the capabilities of a west of England hill-farm.

The Agreement.—The letting of moorland upon equitable terms embraces an extensive range of topics for consideration.

First, we have the "lord of the soil" to consult, and next to find a suitable tenant for the work to be done. These parties either do or should meet upon equitable terms, in the character of two men meeting to make a bargain, the result being, "If you will do this, I will do that."

The first business will be to arrange the general principles of the bargain. The landlord will probably agree to erect suitable buildings, fences, to make roads, &c., and to perform all drainage, the tenant paying a proper percentage for this latter outlay. The tenant will then have to reclaim all lands and wastes (worthy of cultivation) under suitable covenants.

The carriage of materials is usually thrown upon the tenant, or in other words it forms a part of *his* agreement towards the matter. This is a stipulation which I have long thought, at least upon this class of farms, objectionable, and it would be well at any rate to postpone bringing it into operation, for the tenant will have enough to do with his teams, during the first few years of his tenancy, in reclaiming these rough and rugged lands.

In after years this subject may be more fairly pressed, and thus made agreeable to both parties, by the tenant doing the carriage for future permanent improvements, and so encouraging the landlord to keep pace in his outlay with the progress of land cultivation.

With such an understanding clearly defined, every possible and prudent encouragement should be given to the tenant. First, by a long lease with breaks in it, to allow the tenant to quit at the end of a certain number of years, should he wish it. Second, by a proper tenant-right for unexhausted improvements at the end of either term, to prevent the farm being run out towards the end of the term. Third, by the adoption of the plan of a "scale of rents," commencing at the lowest possible figure in the outset, and increasing every four years to the end of the term, as the farm improves in value.

To illustrate this last point we may suppose a case, viz.—that a farm is let for 20 years; that the tenant may quit at the end of

8 or 16 years, and that the average value of the farm for the whole term is 10s. per acre; the scale of rents in this case would run thus:—

	s.	*d.*	
1st 4 years, average	6	0	per acre.
2nd "	8	0	"
3rd "	10	0	"
4th "	12	0	"
5th "	14	0	"

Thus, should the tenant quit at the end of the first terms of his lease, he will only have paid the lowest rents during the period of making his major outlay.

In illustration of the second point—compensation for durable improvements—I subjoin a copy of a Memorandum which I have found highly satisfactory to the tenants on the property of which I have the care as resident agent.

Memorandum.

In order to encourage the tenant to cultivate the farm in the highest possible manner, the said hereby engages on behalf of himself and his representatives, owners of the farm let to the said , ON CONDITION of the foregoing covenants having been fulfilled and kept by the said , his executors or administrators, that when the said , his executors or administrators, shall quit the said farm, either at the expiration of the lease for years, under which he holds it, or at the expiration of years, as by the said lease provided, and not otherwise, the said or the incoming tenant will allow to the said or his executors, administrators, or assigns, for such improvements made on the said farm, subsequent to the date of this memorandum, and within the stated period before quitting, as are contained in the following list, and are marked and enumerated with the figures ; that is to say, so much of the amount of such expense as shall be in the given proportion, in each case, to such a number of years as the said , his executors, administrators, and assigns, shall fall short in the occupancy of the said farm, after incurring such expense: IT BEING EXPRESSLY STIPULATED THAT THE TENANT IS TO GIVE AN ACCOUNT EACH YEAR of such outlay as he proposes to make in DURABLE improvements, in order to obtain the owner's sanction in writing to the proposed expense, SUCH SANCTION BEING NECESSARY IN ORDER TO CLAIM OR BE ENTITLED TO ANY ALLOWANCE from him; and shall also render an account of such disbursements within each year,—such account to be examined and signed by the landlord, or his accredited agent, and to serve as a voucher for the sums so to be recovered by the said tenant; and that non-payment of rent (if the same shall have been demanded, and afterwards remain unpaid for the space of six months) or non-fulfilment of covenants shall FORFEIT any claim or right to such allowance for improvements.

The proportion of the proposed conditional allowances to be regulated as follows:—

1st. If the tenant drains the land at his own expense, with the consent and subject to the inspection of the landlord or his agent, an allowance to be made for the materials and workmanship, for [*eight to fourteen years, as the case may be*] years, so that the allowance shall yearly diminish in equal proportions, and be cancelled by years' enjoyment of the improvement.

2nd. For lime used on the land, with like sanction; the allowance to extend in like manner for FOUR years.

3rd. For bones used on the land, with like sanction; the allowance to extend in like manner for THREE years.

For other manures, as the case may be.

4th. For subsoiling peat-lands, with like sanction; the allowance to extend in like manner for FOUR years.

5th. For making and planting new fences, with like sanction, the same being left in a good and growing state; the allowance to extend in like manner for FOURTEEN years.

6th. For making water-meadows, with like sanction, the same being left in a good and tenantable state; the allowance to extend in like manner for [*four to eight years as the case may be*] years.

7th. For buildings erected on the land, with like sanction, the same being left in a thorough repair; the allowance to extend in like manner for TWENTY years.

And the said and hereby mutually agree that if any dispute shall arise between the said , their executors and administrators, upon the said quitting the said farm, or upon the state of cultivation or condition thereof, such dispute shall be settled by two referees, one named by each party, or their umpire; and in case one party refuse to nominate a referee within ten days after notice has been given in writing by the other party, the referee of the other party alone may make a final decision.

If two referees are appointed, they are to nominate an umpire before proceeding to business, and the decision of such referees or umpire, as the case may be, shall be final.

WITNESS the hands of the parties.

The landlord should reserve, at least on strata deficient in lime (as one of his conditions), that no land shall be broken up from its original or natural state without being properly and sufficiently limed, that is, with at least 2½ to 3 tons of lime per acre, upon which the landlord will stipulate to pay his proportion, according to the annexed memorandum.

In the event of the tenant commencing upon a small yet eligible site for additions, as has been previously named under the head of "Buildings," it should be agreed that only a certain amount of buildings should be erected, or rather, that a certain amount of money should be spent in buildings each year, that is, just so fast as they are required for use, instead of erecting *a mass* of buildings in the outset, many of which must remain unoccupied until the farm shall have so far advanced as to require them.

The enclosure fences to be erected by the landlord should all be properly specified in the agreement and upon the plan of the farm, leaving all subsequent divisional fences to be agreed upon as the work proceeds; as so much depends upon the turn things may take for or against the farm. In the carrying out of these subsequent agreements there need not be the least difficulty, provided that both parties meet on the footing of having a mutual interest in the progress of improvement as fast as their respective

capitals can be laid out with a prospect of reasonable return; and that the consideration of these two distinct interests is regulated by mutual confidence and good will. *In no instance* should a new fence be erected until the land is required for cultivation, as it would be absurd to enclose rough lands (or a whole farm) before they are actually wanted for improvement. The cost of fencing is a high charge upon "open lands;" but with an increasing population, and consequent increased consumption of food, we have a good guarantee before us that our increased produce will find a ready and remunerating market; so that the investment to be made by the landlord, coupled with that of the tenant, may fairly be classed amongst the safe calculations of the day, and a proper return of interest for his outlay may be expected. In saying this I must, however, add, that the outlay should be judiciously adapted to local circumstances, and that too much should not be expected at first, as the value of the "fee simple" of the estate will be steadily increasing (as shown by the scale of rents), if the tenant is well and efficiently encouraged, and may ultimately warrant even a more extended outlay in permanent improvements for the further development and beauty of an estate. There is no safer investment than well-directed capital in permanent improvements; and far better would it be to improve a property already in hand than to extend the acreage by purchase of additional lands.

Cultivation.—The first operation in the cultivation of an unimproved hill-farm is that of draining. Draining is a subject on which so much has been spoken and written, that it might have been lightly touched upon here were it not for the peculiar circumstances which on moorlands serve to modify general principles.

Drainage has now fairly become a science, and nearly every farmer is so far advanced in this science, blended with "practice at his finger-ends," that he becomes his own "director of a company of drainers."

So far as I have yet seen and practised the art of draining in a hilly country, my choice would most certainly fall upon native talent—men who have grown up with the systems proved by continued practice to be best adapted to their particular stratum, rock, or district.

The drainage of any lands naturally depends upon a proper knowledge of the position, depth, and direction of the strata to be dealt with, as well as of their relative porosity or power of transmitting water, or impeding its passage.

The angle at which the surface of moderately-sloping hills inclines to the globe's surface is a matter to be attended to; but with reference to the moorlands on the western portion of the

island the superficial inclination is less important than that of the dip of the strata. These lands are generally composed of materials lying in a stratified order, and in oblique or slanting directions downwards. Some of these strata are capable of admitting water to percolate through them, while others are altogether impervious, and thus force it to filtrate near the surface, and in that way conduct it to the more level lands below, and render them moist and swampy. The rocks, or strata which constitute hilly or mountainous tracts are often found to be continued in much greater regularity than others. The rain that falls, as also the condensed moisture, thus sinks through the superficial porous materials and passes on to the closer strata at a lower point on the sides of such elevations, until it is retarded by some impenetrable substance, such as tight rock or clay. At this stage it escapes at some low position, and oozes out in the shape of "springs," which sometimes appear at a uniform level for a great distance along a hill-side, poisoning all the ground below them. These springs are governed in their discharge by the extent of the high ground on which the moisture is received and detained; while bog-springs are those that empty themselves at the foot of high eminences, and form swamps and morasses.

The object to be attained in draining these bog-lands is not therefore to catch the surface water, but that which flows from the spring-head. For this purpose it is necessary to cut a deep "open drain" from bottom to top of the valley, commencing at the lowest possible level, care being first taken that the washings of these open drains be conveyed by "water gutters" to some adjacent dry hillside, as by a little management nearly the whole of the soil to be removed from the open cutting may be washed away by the passing current, rather than lifted up to the adjoining bank, which by reason of the pressure upon the bank side too frequently runs in again.

On reaching the *head* of the bog or swamp care must be taken to "drive up" a deep and efficient level to the "spring-head," for tapping and carrying away the stream that there issues from the "tight rocks." This deep cutting will prevent the escape of any water into the old underground drains or currents.

This main outlet should then be left for a time to settle, and to afford an opportunity for observing what amount of good has been accomplished, and what remains to be done.

The after process is to tap all springs that remain at the sides or otherwise, and so conduct them as to empty into the permanent open drain.

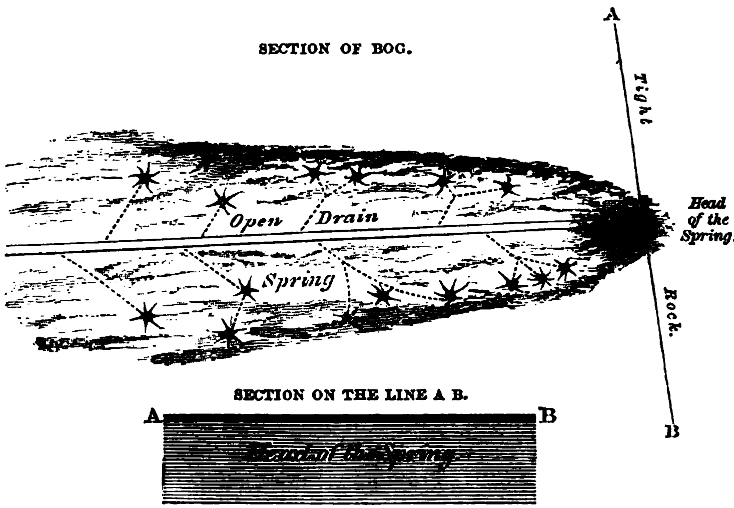
For cutting these drains through peaty soil, and say 6 inches into the fixed strata below (to prevent the possibility of the water slipping the drain), we usually pay at the rate of 2*d*. per foot

downwards for a perch of 16½ feet in length; but in the case of mixed cutting, where rock intervenes, a small increase in price is usual, making it, upon an average of drains and depths up to 4 feet, at the rate of 2½*d.* per perch for the cutting.

The general cost for cutting, stoning, and filling-in runs thus:—

	s.	*d.*
Cutting drain 4 feet deep, at 2½*d.* per perch	0	10
Quarrying stones for drains	0	5
Setting the stones 15 inches high and filling in the drains	0	5
Carriage of stones is invariably done by the tenant.		
	1	8

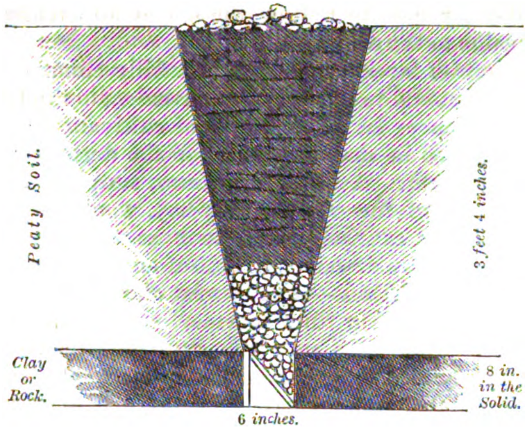
The cutting of all drains upon lands which have been formed by deposits from time to time must, as a *standing rule* (never to be omitted), be always cut from 6 to 8 inches into the bed below, so that when filled in with stones these may be fairly placed below the old current of the passing water.



Assuming that the head of the bog, as also all other upright or side springs, are drained, and the land itself sufficiently settled for improving operations (after lying some months), some consideration is necessary as to the better plan of doing this, which will be treated upon hereafter.

Occasional Springs.—Should springs occur at particular levels on the line of rock, and upon the moderately sloped lands, it may be best to check their descent by making horizontal drains of some length across the declivities of the hills, and thus conduct or empty them into the nearest brooks or open ditches. But should these horizontal drains run in line with the strata or strike

SECTION OF DRAIN.



of the country, it will be necessary to keep them a little below the porous stratum that supplies the water, and cause occasional *upright* drains to be driven across them; by this means the upper line of water issuing from behind some impervious bed or rock will be effectually tapped and cured.

In ordinary cases of draining, care should be taken to lay out the drains so as to *cross the line* of strata at right angles; by this plan many acres will be laid dry by means of a single deep drain, while numbers of drains cut *with the line* of country have done but little or no good.

The more feeble springs that empty themselves upon the sides of the hills, and often at a low range, through some loose or porous soil, shakes in the rock, or otherwise, are best *tapped* by a short level, and at a tolerable depth: these should be so arranged as to be placed in immediate connection with the "water-gutters" that are passing at their foot, so that the latter may receive the drainage water. These water-gutters should be set out before the draining is executed, and the outfalls of the drains and the lines of the water-carrier should be considered in their bearing upon each other. The water issuing from underground drains is generally excellent as irrigation water, although if it had been allowed to ooze out through the vegetable matter near the surface it would have done nothing but mischief. The material used for draining in an elevated country is usually native stone, which is quarried upon the spot and found to be much cheaper than tile or pipes.

Again, in practice it is found that liberally stoned drains in a stormy district carry away these sudden gushes of water more effectually than the small aperture of a tile or pipe. Pipes of

large dimensions would of course meet this difficulty, but the outlay would far outstrip that of the stones and really be of no increased value to the drains.

The carriage of foreign materials in a hilly country is always a formidable affair, and is never *quite* convenient to the tenant when making his advances in other works of cultivation. The teams are better engaged in drawing lime for the decomposing of the reclaimed bog-earth. A *portable railway*, supplied by the landlord for the use of the general property, would be an excellent means of meeting extreme cases, such as the improvement of bogs or hill-sides, by dressings of soil of an opposite character.

Peats and Flow Mosses.—The lowest class of peats are those designated the "peat or flow mosses," such as are common in Ireland and Scotland. These are usually situated upon flat ground, lying upon underground basins, impervious to drainage and natural outfalls, and thus an accumulation of stagnant water breeds a collection of coarse aquatic plants; and as one moss or grass decays, another is found to spring up upon its decayed remains, and so on for ever, until arrested by enterprise and capital. These stagnant bogs may well be compared to a sponge which has been filled from time to time, even to overflowing, and thus becomes useless—once *emptied* of its fluid the sponge is convertible to other and better uses. Below these morasses are found even good furrows of earth, on which trees have grown in former ages, before these flats and basins became so far inundated and saturated by stagnant water.

To mark the original cultivation and habitation of these lands I may quote the late Arthur Young's remarks contained in his 'Irish Tour:'—

> "Mr. Rowley keeps a very considerable domain in his own hands; adjoining to it is a black turf bog of admirable use for firing. I viewed it attentively, and am clear that all such bogs as this, with a fall from them (!) for draining, might easily be improved into excellent meadow. They have found at 14 feet deep evident marks of the plough in the soil at bottom, also remains of cabins, cribs for cattle, mooses' hornes, oaks, yews, and fir, being good red deal."

Here we have a striking instance of original fertility superseded, or we may say literally swamped, by neglect. The question for modern art is, How can this huge mass of vegetables be reduced, at the least expense, to a state of complete decay? How can it be made (what other masses of vegetables are made) a dunghill for poor lands, or, where it lies, be converted into an inexhaustible fertile soil? If water is the originating cause of a peat-moss, take away the water, and it is surprising how soon a deserted morass, bog, or channel of a river, obtains verdure and suitable plants for its improved occupation. If the

plan of subsequent tillage is adopted, the growth of potatoes is found to be one of the most productive and profitable root-crops, but on reclaimed lands there is no doubt of raising succulent crops of any kind, or of their weight being proportioned to the spirited culture of the land. Not so with the cereal crops, as they are generally too luxuriant in their growth, and become faulty from the softness of their straw. The laying down of such lands into permanent grass, after some few root-crops have been grown, will be found the more safe and profitable plan, being more in accordance with the soil, situation, and habit of such lands as are yet too full of undecayed vegetable matter for the growth of corn.

Amongst the more prominent results in the reclaiming of peat or flow mosses are those recorded in the Society's Journal, vol. x. p. 1, and contained in the Prize Report of the Farming of Lancashire, viz. Chatt-Moss. This extensive moss is situated within a few miles of Manchester; its area is about 6000 acres. Many had been the attempts to drain this morass previous to the period of 1834, when a more comprehensive view of its form, depth, character, and outfall was taken, and these obstacles mainly overcome. The triumph is now nearly complete. An ingenious plan of applying marl upon the drained surface has done much for its solidity in the outset. Other agents were subsequently employed upon remaining portions, none affording better results than the application of "lime and salt" as a top-dressing: this corrected the mossy tendency of the soil, and proved of infinite value. The report above referred to is worthy of careful perusal, and renders any further detailed accounts unnecessary, beyond the practical remark, that, by whatever means these bogs are reclaimed, certain it is that no other meadows surpass them, and that they rise to a marketable value corresponding to that attained by other lands.

Tops of Hills.—On the summit of hill-lands occur the more general or common peats, such as are usually cut for fuel: these, having been occasioned by stagnant water upon a comparatively level base, which has no natural drainage, are left dependent upon the sun's rays for evaporating its accumulated moisture, to the no small annoyance of a surrounding district. These, by a nice art in the adjustment of outfalls and levels, may be much improved by open surface gutters, whereby even occasional hill springs may be led into them and carried along to some convenient slope for irrigation, by means of slightly inclined gutters, taking care to avoid the injury of too rapid a descent after heavy rains. These tributary streams empty into others of somewhat larger dimensions, and these again into a "floating gutter" for spreading these so accumulated surface waters over the mossy

dry hill-sides, whereby these weeds and other inferior grasses are destroyed, and the better ones are encouraged to take their place.* From the irregularity of the declivity of some hill-sides, alternate patches of wet and dry ground appear: these wet spots are usually formed by the drainage of the upper surface water upon them, and are thus changed in their character by an accumulation of aquatic roots being grown and decayed upon them from time to time. In the arable culture of these wet spots it is found best, first to cut off the supply of surface water, and then at a suitable time of tillage to *subsoil* them to break what is provincially termed "the pan." This is a crust of iron sediment upon which is usually formed another sediment of clayey matter: these require to be moved (broken up) before the water can possibly percolate through them into the subsoil below, but when once this has been performed all is well, and these hitherto neglected, yet deepened soils, become the best for after culture in the growth of artificial grasses.

The draining of mixed soils at the foot of hill land, where clayey formations and deposits abound, is considerably more tedious and difficult than where the superficial and internal parts have greater regularity. Sand beds or sediments of any kind, interspersed with clay beds, having no communication with each other, require so many drains as there are different beds, and consequently the group of drains becomes very complicated. In this instance it is better to decide upon laying out one main drain, taking care that it passes from the nearest and lowest part of the flat intended to be drained up to the highest sand bed, and causing it, if possible, to pass in its course through or immediately under some of the intermediate sand beds, the remaining beds being drained into this general outlet. Where a thick deposit of clay is found resting upon sand or gravel, but one course remains for adoption, and that is, to cut a drain through the bed of clay until the passage of the water shall have been reached; but it may yet happen that the land is not properly drained, and that a succeeding cutting through another bed of clay may have to follow. Where difficulties of this nature occur it is always best to ascertain the depth and *nature* of the strata by the sinking of PITS in various places, taking care that they are sunk in the direction of the intended drain. These should be formed in size suitable to the probable depth they have to be sunk (according to the nature of the ground), as they must be carried down until the bed of sand, gravel, or rock is reached

* Care must be taken, however, to exclude the dark peat-water from the irrigation gutters, as it is poison to water-meadows.—T. D. A.

that contains the water. In extreme cases recourse has been had to boring with boring rods to ascertain at what depth the stratum containing the water lay. This species of examination or test has the merit of preventing any random or uncertain work in the laying out of speculative drains, and affords data for judging of the depth and substances to be dug through. The laying in of drains upon sand or gravelly bottoms is a very hazardous operation, and care should be had in the proper selection of materials to carry off the water.

In the character of country now under discussion it is found best (when passing these beds) to lay a layer of flat stones along the bottom of the drains, and then place pipes with collars along the line of centre, and fill up the sides with stone. Where stone alone is used, the plan of setting the side stones upon the joint of the bottom stones has been adopted to advantage, the drain being completed with broken stone in the usual way—the chief feature in either case being to take care that the bottom stones are equally weighted at either end, or they may pitch at one end and thus spoil the drain.

In my own case, at the early stage of taking these wastes, or rather morasses, in hand, I adopted the plans of trenching, double digging, ploughing by horses walking on the *side* of the furrow, &c.; all of which plans I have since proved to be far too expensive in the outset, as this amount of time and capital could be better employed upon other lands, until the bog had become perfectly settled by consolidation.

My subsequent plan has been to concentrate or conduct a body of water at the higher level of the bog-land, and then wash on to it soil of any kind that could be had in its neighbourhood by means of "water-carriers:" this deposit is placed thickly upon the mossy peat, and with the assistance of lime it promotes the growth of new natural and improving grasses, to the exclusion of the sedgy mosses, which decay, and ultimately form a second manure for future roots to feed upon. It must ever be remembered that "economy of design and practice" should be so blended as to produce the greatest possible return from a given employment of capital—and this in the present instance has to be done upon a rude and rugged waste, acres of which are waiting *their* turn for a share of the outlay. Thus it is found in general better to expend capital in the outset over many broad acres, than to confine a heavy outlay upon some few acres of bog, however inviting may be the greater ultimate return in the distance. The result of my trenching plan, &c., was tolerably good, but the latter plan I found to be much better, and a great relief to my labour account while other improvements were going on. The cost per acre of redeeming the bog by cultivation stood as follows:—

Drainage.	£.	s.	d.
Cutting an open drain up the centre to the head of the spring—16 perch, or 4 chains, at 4*s*.	0	16	0
Tapping upright and side springs into open course—52 perch of 4-feet drains, cut, stoned, and filled, at 1*s*. 8*d*.	4	6	8
	5	2	8
Cultivation.			
Trenching 14 inches, by 2 spits deep	3	5	0
4 tons of lime and carriage	4	3	4
Horse and manual labour in cultivating, sowing rape-seed, &c.	1	0	0
	£13	11	0

In return for the above outlay I had a crop of rape (coleseed) worth 3*l*. per acre, which was fed off by sheep to consolidate the surface. The land was then winter ploughed to the depth of the settled trenching, and cleaned in the spring, previous to being sown down with permanent grasses for subsequent water-meadow. The meadow is now a good one, and of infinite value to the occupation, but its cost, to my thinking, was far too much "to repay a tenant's outlay." Hence the cheaper plan (above alluded to) suggested itself, and has since been generally adopted: its cost is small by comparison, and of course not so immediate in its return; but time has shown that great things may be done upon rough, low-lying lands, by more simple and inexpensive means. I give the cost:—

	£.	s.	d.
Drainage, as per former statement	5	0	6
Paring off all banks and levelling in a rude way	0	10	0
Cutting water-gutters	0	10	0
Raising and washing out soil to the land by means of floating it on by the water and gutters	0	10	0
3 tons of lime, and carriage, spread upon the land after the above process	3	2	6
Brushing and other labour	0	2	6
	9	15	6
Grass-seeds may or may not be sown with this plan, at a cost of say	0	10	0
	£10	5	6

Another yet cheaper plan has been found to answer remarkably well, and the meadows are now producing excellent herbage both as to quality and quantity, viz.:—

	£.	s.	d.
Drainage, as per statement	5	0	6
Paring the rough grasses and levelling them in, &c. ..	0	15	6
Guttering for watering and washing out soil for the land	0	10	0
Labour in raising and washing soil	0	10	0
No lime		..	
	£6	16	0

In cases where the advantages of "washing out soil" cannot be attained, it may even pay to cart decayed mould or peat on to rough uncultivated lands, but in this case I should prefer the plan of cultivation, as the carriage of soil is always inconvenient and expensive in comparison with the return it affords.

It may be thought that to eradicate the aquatic and other natural grasses would be the safer and certain way of improvement, but practice and patience have shown me that nature has much to do in the adjustment of these matters—to adapt nature's grasses to nature's laws and elements. Thus it is best to pursue the cheaper plan of improvement when making water-meadows.

The reclaiming of bogs and peat-soils in a corn country is another matter, as the growth of root-crops and grain would be a preferable course to adopt, and would make a proper and suitable return for the larger outlay.

Cultivation of the Natural Soil.—The first ground selected for culture will naturally be near the house and yards, that some few small fields may be quickly broken up for roots and subsequent crops for the yet small but varied stock of the farm. Paring and burning the surface soil is the first step (in the right direction) towards improvement; then follow the usual ploughings, barrowings, dressings, &c., for a root-crop, which is invariably a good one, and produced at a comparatively cheaper cost *per ton* than those grown upon the inland turnip soils. This may be lightly received, especially when we consider (at first sight) that the one is a rough uncultivated barren waste, and has to be reclaimed, while the inland field savours of all the advantages of improved culture: these are wide odds at starting, but when reduced to paper are not so formidable at the end of the race.

Comparative Cost of Cultivating an Acre of Hill Land, at an elevation of 1000 feet, against an Acre of Lincoln Heath, both being prepared for Turnips.

*Lincoln Heath, Turnip-fallow.**

	£.	s.	d.
By rent and parochial rates	1	5	0
By 3 ploughings, at 8s. each	1	4	0
By cross draggings, rollings, harrowings, drilling, manure and seed, &c.	0	10	0
By 20 bushels of bones, at 2s. 6d. (or other artificials to the same value)	2	10	0
	£5	9	0

* The figures here given were given to the writer about eight years ago by one of the best Lincoln Heath farmers.

Unreclaimed Waste (dry land).	£.	s.	d.
By paring and burning	1	0	0
By one ploughing, 8*s.*; dragging, &c., 3*s.* 6*d.*..	0	11	6
By 2½ tons of lime, at 20*s.*	2	10	0
By rent and rates	0	7	6
By sowing turnip-seed	0	1	0
	£4	10	0

The weight of the root-crop would in all probability be in favour of the new land. The ashes resulting from the burning of this thick coating of indigenous plants are found to be powerful agents for the production of roots, but little good is really effected without the aid of lime to mix with the fibrous earth beyond the growth of a turnip of inferior size. By way of testing these matters I determined to try certain experiments with varying quantities of lime, which was the more important to me as I had decided that the amount of money to be expended in the purchase of artificials should be laid out in lime, the *great essential* for newly broken-up land. The soil should be as far as possible pulverized to mix readily with the lime.

Different Experiments, each upon One Acre of Land.*

Time of Sowing.	On Natural Soil, without Ashes or Lime.	With Native Ashes alone.	Native Ashes and 1 Ton of Lime.	Native Ashes and 2 Tons of Lime.	Native Ashes and 2½ Tons of Lime.	Native Ashes and 3 and 3½ Tons of Lime.	Quantity of Lime applied since the Experiments.
June 1	Came up weakly and died away again.	Produced 6¾ tons of turnips.	Produced 12½ tons of turnips.	Produced 18 tons of turnips.	Produced 20½ tons of turnips.	Produced 22½ & 23 tons of turnips.	As a standing rule, 2½ tons per acre.

The turnips have usually been drilled fourteen inches apart on the flat, with a few loads of ashes per acre (collected in the same field), and the crops have fully realised my expectations. These have been partly consumed upon the land, and partly carted away on to neighbouring dry lands—taking especial care to have a good quantity in "pits" for rough hill-country weather.

In the earliest stages of cultivation and progress some portion of the turnip land has to be sown with oats for the use of the yard: this should be done (at as early a period as possible) in

* A sack which will hold 4 bushels of wheat usually contains 2 cwt. of lime, such as we use in this neighbourhood. 2½ tons will therefore be the same as 25 sacks. The price of the lime at the kiln's mouth at Combe Martin is about 1*s.* per sack. I estimate the cost of carriage at about the same amount as the price of the lime.

the month of March, and upon the land that was first cleared of its roots, the later eatage of roots being upon those lands that are intended to be sown down with artificial grasses, without a corn crop.

When the farm is sufficiently advanced, I much prefer the following course of cropping (for elevated lands):—

First year. To pare and burn the natural herbage, for a root crop, and apply 2½ tons of lime per acre, mixed in with a moderately thin furrow of soil, say 2½ inches; this will produce 20 tons of turnips per acre, at a cost (as previously stated) of 4*l.* 10*s.*—say 5*l.*—per acre, or at the rate of 5*s.* per ton.

Second year. Formerly I adopted the plan of sowing two turnip crops in succession, for the reason that the second one was an inexpensive and convenient one, and enabled me to clean the land more effectually before sowing it down with grass-seeds.

My present plan is to seed out all lands after a turnip crop with proper artificial grasses, omitting the corn crop at this stage of culture, and until the new fibrous soil shall have had its frolic and become more fixed and consolidated for the growth of corn.

When these grass-seeds are sown, it is both desirable and profitable to add half a dressing more lime (1½ ton), for their enjoyment and that of the farm stock when depasturing them; still it is an extra outlay of capital that must be considered with reference to other expenses when so many other works are waiting to be performed, and these alike with tenant's capital.

Thus, after the turnips are consumed (chiefly upon the land), the land is carefully ploughed, cleaned, and sown with artificial grasses and rape-seed, commencing the first week in April.

These young grasses will be ready to stock by the end of June, and, if allowed to get well established, they will usually fatten full ten sheep per acre, and if care be taken to clear them occasionally, so that they sweeten and recover themselves, they will prove of infinite value up to Christmas. If they remain clear from the end of September for the ewes and lambs, which is a still better plan, they give a help over the inclemency of the months of March and April, after which they become first-rate pastures for the fattening of any class of stock, and maintain their comparative goodness for several years.

This plan of farming in an elevated country goes very far to conquer the climate and to enable the farmer to maintain a large and healthy flock of sheep: in fact, it may be said to form the *keystone* to the whole structure—without it, the building is in danger.

If any practical man will take into account the newness of the soil, coupled with the preceding management, according to which *no corn crop* will have been taken out of the land, I leave it to

him to judge what comparative return may be fairly expected from stock in after years in a hill country remote from corn-markets, but where all animals can readily be fatted and *walk* to market, with the produce of the farm upon their carcase.

The grasses to be sown should be those which have the qualifications for quick and abundant growth. During the last few years I have sown the following quantities and qualities, at an average cost of—

	Per Acre. s.	d.
3 pecks of Pacey rye-grass, at 6*s*. per bushel	4	6
1 peck of Italian rye-grass, at 6*s*. 6*d*. per bushel	1	7½
4 lbs. of Timothy grass, at 6*s*. per stone	1	9
2 lbs. of cow-grass, at 9*s*. 6*d*. per stone	1	4
4 lbs. of white clover, at 10*s*. per stone	2	10
3 lbs. of rib-grass, at 6*s*. per stone	0	5
Small quantity of parsley-seed	0	8½
	13	2

While I believe it is admitted that corn is liable to be lodged and spoiled upon new land when sown after the first root crop, it is equally worthy of note that *no land* can well be too rich for the growth of succulent grasses. However luxuriant these may be, they can at all times be overtaken by good management, and kept in good and respectable order; and, as time goes on, these pasture lands may be safely and profitably cropped with corn, especially oats, and afterwards renewed again by roots, &c. These pastures remain *good* about four years, and then require to be broken up for oats, thus completing a seven-years' course of cropping. Then follows the usual routine again, viz.—

	Acres.
1st year, roots—say	30
2nd year, rape and grass seeds	30
3rd, 4th, 5th, and 6th years, pasture	120
7th year, corn	30
	210

In the making of subsequent improvements upon the grass-lands, there is no outlay more simple and efficient than the use of decomposed vegetable mould, mixed, about six months previous to use, with lime or salt, and then carted on the pasture or "dry meadow" lands, at a short distance from the mould or compost heaps.

We have carted out many hundred loads of these decomposed vegetable soils *without* the aid of any artificial mixture, and the effect upon brown *dry* land has been surprising, and in many cases fully equal to that of farmyard dung. So that occasional bogs at different parts of the farm prove to be valuable adjuncts

rather than objectionable swamps. But this is only possible after drainage, and that of some years' standing.

As previously remarked, grass-land is to be classed under three heads,—1st, the water meadow; 2nd, the enclosures under grass in course of cultivation; 3rd, the open or hill pastures.

The hill land is used for summering ground, and some few native sheep and ponies are turned out to "pick a living" during the winter as best they can. The rough grassy hills will keep at the rate of one full-sized beast upon three acres from the 1st of May to the 1st of October. Upon the forest of Exmoor, Somerset, large blocks of land containing some thousands of acres are depastured in this way, cattle being kept during the above period at the following prices:—

		£.	s.	d.
Cattle.—	Three years old and upwards	1	0	0
	Two years old, and under three years	0	15	0
	Yearlings, and under two years	0	12	0
Sheep.—	Any age, including young lambs and shepherding	0	2	3
Horses.—	Horses of any age	1	5	0
	Ponies for the summer	0	15	0
	Ponies for twelve months	1	5	0

No difficulty is experienced in getting a sufficiency of stock, and some parties have continued their custom for a period almost unknown.

The return afforded by the above plan is at the rate of from 3*s.* 6*d.* to 4*s.* per acre, in addition to which a goodly number of breeding ponies are kept by the proprietor, making an additional rent of say 1*s.* per acre, and this without the aid of extra fences, roads, or buildings.

The taking in of cattle to summer upon these hills and the adjacent farms is now an established custom, and any number may be had from the neighbouring corn lands and dairy districts. The latter farmers usually place out their yearling heifer stock, and the former parties send their steers and in-calf heifers. There is also a rather extensive practice carried on by other parties, who consign their better animals to the north Devon farmers for summering upon what is provincially termed "best keep," and for which they pay a higher rate,—in most instances about double the price charged upon the forest hills: this is a practice equally agreeable to both parties, and has existed for generations past.

The meadow-lands, owing to their more fortunate position for shelter (at the foot of the incline) and for the reception of all washings of soil and manures from the upper lands and from the farm, have every advantage for improvement, and the production of abundant hay crops without the aid of farmyard manure. This manure is usually carted upon the pasture lands above the

yard, as, when used upon the arable fields for roots, it is found to encourage the growth of "chicken weed" to such an extent as to puzzle the cleaner of a root crop, however well studied his plans of sowing and cleaning may have been.

Catch Meadows.—The subject of hillside catch-meadows in a rough and rugged country abounding with valuable springs and a rainy climate cannot well be too forcibly dwelt upon, and the more so as I have mown full two tons of hay per acre from this class of meadows when properly improved, which some seven years past were *worthless* hill-sides, and this to the full extent of some 50 acres—made upon the natural dry hill-slopes, at the nominal cost of 12*s*. per acre.

As so much has been written upon the formation, value, and cost of "catch-meadows" in the Society's Journal, vol. xii. p. 1,* I cannot do better than refer the reader to that essay, affording as it does the best practical information I can give upon the subject of water-meadows.

Stock.—The stock found best adapted to elevated moorland districts, whether reclaimed or not, is a class of thick-set, short-legged animals. These are much more hardy than the more refined breeds, and, from the nature of the climate and general produce, they are found to pay more money per acre. If animals of higher quality be placed upon elevated lands, they will quickly degenerate into a moderate ill-shaped animal, and thus become ill adapted to the elements and requirements of their new home.

Summer occupation of high land.—Where unreclaimed lands are situated within reach of cultivated farms, and the buildings already erected, it is IMPORTANT to encourage the present tenants to extend their operations to the "open waste," whereby the return would at once be two-fold, and the climate and appearance of the neighbourhood steadily improved.

There is another and an important plan that may be adopted in the reclaiming of moorlands: it applies especially to remote situations, such as do not warrant the erection of a good and substantial farm-house and buildings, or a desirable residence for a respectable family. In such cases a class of summering farms should be so set out as to afford facilities for an entire "stock farm," *little* or no corn being grown. The breeding and feeding of sheep would constitute the principal occupation and return of the farm; the *summering* of cattle and colts would form merely a useful adjunct for the time, and might pay something towards rent and labour. Such an occupation would require but little outlay in buildings; a modern double cottage would be ample as a residence for the bailiff, and afford two spare rooms for the

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* By the writer of this paper.

occasional use of the tenant. The farmery would only require sheds for some two or three cows, pigs, &c., for the bailiff, and stable-room for the horses in summer. The working oxen (of which a goodly number should be used) would require no extra attention in sheds during the summer season, and this would be the *only* period when cultivation, upon such a farm, would be going on.

I subjoin a sketch of the course to be adopted, so as to make the most of the summer, and to lighten the difficulties incident to a long and profitless winter:—

The boundary fences being in good order, the plan of the intended fields laid down, and the first enclosure made, we commence by paring and burning the native turf. Meanwhile a suitable number of oxen and general outfit are being collected, and the first crop of roots is well in by the end of June. Upon this land 2½ tons of lime per acre should be spread; this may be carted by hire, at per ton or otherwise, so as to simplify the occupation.

In July some rougher lands, such as cannot be pared, may be ploughed and dragged for burning, then ploughed up for the winter, to lay for subsequent tillage in the spring for Swedish turnips. The oxen are then rested during the winter months and kept cheaply, or they may be partly sold and replaced the following spring.

In March the turnip lands will be ready to commence upon with the ploughs (while the paring of other new lands is proceeding as before), and subsequently prepared by the first of April for sowing with grass-seeds and rape, without corn, to be fed by fattening sheep in July. Then follows the programme as in the first summer, for roots, &c. One or two pairs of horses may be kept for convenience, according to the necessities of the farm, large or small. Thus, as the farming proceeds, and with it an extension of grazing lands, it may be well after a time to place in a few young cattle upon these lands for the summer months. Upon the yet unreclaimed lands summering cattle, ponies, or store sheep may be kept.

By this plan of farming a provision of roots is made for the winter and spring use; young grass, one or more years old, will follow for the early grazing; and the rape and young seeds for the fattening of all sheep required to be sold, or the growing of such sheep as are to be removed to an inland farm for wintering.

Subsoiling.—I have already spoken of the necessity of drainage, but I must draw especial attention to a nice point on some moorlands, even with porous subsoils, which, from their having a fixed bed of thin clay or iron sediment formed between the surface and subsoil, have lain waste, owing to the fact that no

drainage will relieve them without a proper breaking up of these fixed strata, which can alone be done by deep subsoiling or trenching, to be regulated by the depths of the surface soil resting upon these "crusts or pans" beneath. When within moderate and reachable depth, say 15 inches, my practice has been to "pare and burn" the upper grasses, the paring being done with Glover's plough to a good depth, and burnt during the summer as it lies upon the land: by this process the soil beneath is slightly charred, and no further cost is incurred by spreading the ashes. The land is then half ploughed 4½ to 5 inches deep, and laid upon the adjoining uncut land, thus forming a number of ridges throughout the field, and effectually covers up all the ashes for another day. As this work proceeds, "Comins' subsoil plough" follows up every present furrow (which is ample, as the neighbouring one is also disturbed); and the plough is so regulated as to reach the bottom of the fixed and impervious stratum, and so to disturb it without bringing to the upper soil an admixture of the inert subsoil. The cost stands thus, per acre:—

	£.	s.	d.
Paring by horse labour, viz.:—			
4 horses, man, and boy, to 2½ acres, 15*s*.	0	6	8
Burning and levelling inequalities of land	0	2	6
Half-ploughing into ridges (2 horses)	0	4	0
Subsoiling every other furrow .. } 4 horses, man, and boy, to 2 acres }	0	8	0
	£1	1	2

The ploughing and subsoiling of these lands is done after the season for turnip sowing has passed away, and the horses are set at liberty for this "heavy work." After the work is so performed, these narrow ridges remain until the spring, and thus not only protect the ashes and keep them in store, but at once shed off all waters that may fall upon them, and it is as quickly received and conveyed (somewhere) by the subsoiled furrow below. The winter over, this land is in a state to convert to any purpose—roots, corn, grass, &c.—roots of course being the proper and better crop, for which suitable dressings of lime are procured. The subsoiling of these lands naturally produces a quick change in the under-current of passing waters, and they as quickly show themselves upon the surface at some new point of obstruction, and *must* then be carried off by an occasional drain or two. The result of this subsoiling is immense, causing as it does a complete revolution in the state of the soil so drained. It is proper to mention that the work of half-ploughing the land into narrow ridges, and that of subsoiling these fibrous and *living* beds of earth, require great strength and careful adjustment of the plough. I have given my figures of the cost for the

work performed by horses, but my usual plan has been to perform this operation with the "working beasts," six in a team. The working of oxen, while reclaiming extensive tracts of land, is a good and convenient one, as these improvements always proceed in early spring and summer, and, when done, the cattle may be "tied up" and fatted, while the horse would most probably have to remain upon the farm during the winter months, at a heavy cost and inconvenient attendance, especially at the early stages of improvement, when a stack of hay or corn is a rare production.

The subsoiling of these deep peaty soils is scarcely a tenant's work, as shown by the memorandum of tenant-right. It would be well for the owner of the estate to aid this difficult and heavy branch of outlay by a permanent staff for the purpose, which might go from farm to farm as practical observation suggests his aid.

Trenching.—On such moors as are too deep for subsoiling, and are yet so situated as to command attention and redemption, trenching is a better plan. In this case I have usually skimmed the surface by a paring plough. This is removed by manual labour to admit of the common plough, which goes as deep as circumstances will admit, observing to turn a deep and *narrow* furrow; the trenching then follows. This is commenced at the lowest range of the land, and, when well opened and started, the furrows are "chopped" across, turned downwards, and the trench deepened to its required depth, so as to "break the pan," as before alluded to. The paring furrow, composed of rough grasses, heather, &c., is carefully thrown *under*, each man having his stipulated share of the work allotted to him, so that the company of men may follow each other and complete the work as they proceed. The depth of the trenching naturally depends upon the depth of the land under hand, and if there are any inequalities to be levelled. The removal of the soil beyond 20 inches is a heavy affair, this being so far effected by the plough at 6 inches, and two spits of 7 inches each. After this operation has been carefully gone through (previous to Christmas) the land awaits the winter elements, and in the spring may be safely used for any kind of roots that may be wished, not forgetting the potato-plant upon newly broken-up peat soils. This will assist in the mixing of the strata or soils, and will prepare them for succeeding crops.

I may now give in a tabular form, as a summary of the whole subject, a statement of results founded on my own experience, from which practical men may judge how far moorland improvement may be made remunerative to the owner of the soil in the long run:—

Cost of reclaiming certain portions of Bog-land that are too deep in Flow-moss or other Deposits for Subsoiling, or even (to reach the bottom) by Trenching, showing a Statement of Account, extending over Four Years.

	£. s. d.	£. s. d.
First year's expenditure, at per acre:—		
By share of cost in the enclosure of 5-acre fields	2 16 0*	
By occasional drains, upon an average†	0 10 0	
Paring first furrow (surface-weeds) with paring-plough	0 7 6	
Ploughing second furrow, 6 inches deep	0 12 0	
Trenching (*and levelling*), 14 inches deep, at 9*d.* per perch	6 0 0	
4 tons of lime, carriage, and other expenses	4 3 4	
Harrowing, &c., of land and drilling turnips	0 5 0	
Cleaning and setting out turnips	0 10 0	
		15 3 10
Second year:—		
Ploughing 6 inches deep	0 10 0	
Carting 80 loads of heavy soil, at 9*d.* per load	3 0 0	
3 cwt. of guano for second turnip crop	1 16 0	
Harrowing, &c., collecting ashes for mixing with guano, drilling, &c.	0 12 0	
		5 18 0
Third year:—		
Ploughing 8 inches deep	0 12 0	
3 tons of lime, carriage, &c.	3 2 6	
Harrowing, &c., and sowing of grass-seeds	0 4 0	
Grass-seeds for permanent pasture or renewing	0 13 6	
Fourth year:—		4 12 0
No charge beyond fixed payments	..	..
Other payments: 4 years' rent (rates nominal)	1 0 0	
Interest of capital upon balance of accounts at 5 per cent.	1 5 0	
Wear and tear of implements, &c., for 4 years	1 0 0	
		3 5 0
		28 18 10
Summary.		
First year's return:—		
By value of hybrid turnip crop, 20 tons, at 6*s.* per ton	6 0 0	
Second year:—		
By value of Swedish turnip crop, 24 tons, at 7*s.* 6*d.* ..	9 0 0	
Third year:—		
By value of artificial grasses and rape for fattening sheep	3 10 0	
Fourth year:—		
By young seeds mown twice and after eatage	5 10 0	
Excess of outlay above the receipts of the 4 years ..	4 18 10	
		28 18 10

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* This amount, 2*l.* 16*s.*, is intended to cover the whole expenditure for fences, ditches, roads, and gates.

† In some instances these lands require good and substantial drainage, at a cost of 4*l.* per acre. In such case the clays or heavy soils that are found at the base of the peats fully compensate the outlay when brought to the surface by trenching.

COMPARATIVE VALUE.

	£. s. d.		£. s. d.
When taken in hand, of nominal value, and a pest to the neighbourhood.*		At the expiration of 4 years will readily let for a term of years at 15*s.* per acre, which, at 30 years' purchase, stands thus	£22 10 0
By balance due from the outlay account	£4 18 10		

The above figures convey a tolerably good notion of the expenses and probable returns of this class of improvements, but they are founded on an extreme case; for if they had been performed in a good neighbourhood, the rental, when so improved, would stand at 30*s.* But in either case ample encouragement is shown for the outlay of capital, and a good margin left as profit for the undertaking. In the preceding statement it is shown that no corn-crop has been taken, first from the circumstance of the redeemed land being too open and fibrous for "corn growing;" and secondly, that it should be placed in a good and efficient condition, for reaching a fair marketable value, for an after term of years.

The figures above alluded to clearly show that the bringing of a morass or bog into good cultivation carries with it more the character of a landlord's than a tenant's investment.

So sanguine am I in favour of seeding down (out) these newly-redeemed lands without a corn-crop, that I even adopt it in the usual routine of crops after the turnip-crop upon old land, and reserve the sowing of corn until the end of the course; and then, if it be absolutely required, I should even prefer taking two white straw crops after breaking up the grass, and just previously to the subsequent fallow, to sowing the rich turnip-land with corn in a moist climate. The two after-crops (if they must be taken) would in amount of acres be the same.

Thus the number of corn-crops in a course would be the same in this arrangement as in the other mode of cropping, only with a longer interval, during which the field would be in grass; the great characteristic of my plan would be that the grass would be laid down when the land was perfectly clean and in the highest condition for after-pasturage.

There is yet to be mentioned a class of moorlands, which, from their tolerable dryness and production of strong heather, furze, and other coarse, hard-rooted plants, are found too powerful for the paring-plough or manual paring-spade; but in themselves, when broken up, are of a first-class order for after-culture under

* Such was the extent and character of a bog near to my house that, on making trial-pits for its drainage, a snipe's nest was found, and happily in the presence of the landlord.

a liberal lease. These are better taken in hand one year previous to the sowing of a root-crop, as they require time, and will never pay to be forced into cultivation.

In place of paring the sod, men are engaged to "grub up" all the land, and to set free every existing bush or root; these remain for a time until the weather permits them to be burnt in heaps. This over (the land not being intended for turnips the first year), the soil is ploughed up to the depth of six inches, and as the work proceeds the neighbouring ashes are thrown over it, and so remain for months, until the weather has so far acted upon the soil as to suggest further operations, which generally follow about the succeeding March by scuffling, dragging, cross-ploughing, or other process for its refinement.

Turnips ought to be sown in the next summer under the customary course of management, while some few occupiers, greedy of a corn-crop, will at once place their land under oats, and thus ultimately ruin the "goose" that would otherwise have produced them golden eggs.

The cost is extended over rather too long a period, but if the early stage of the work is done chiefly after the turnip-sowing upon other lands, the process may be termed a good and convenient one:—

Cost of Reclaiming for Roots.

	Per Acre. £.	s.	d.
Cost of grubbing	3	0	0
Burning and spreading the ashes	0	4	6
Ploughing 6 inches deep	0	10	0
Cross-ploughing in the spring	0	10	0
Subsequent draggings, harrowing, rollings, &c. ..	0	10	0
3 tons of lime	3	2	6
Drilling turnips, &c.	0	2	6
Two years' rent and rates	1	0	0
	£8	19	6

This class of moorland is costly to improve in the outset, but practice has clearly shown that there is not a more paying pursuit in agriculture than that of their permanent improvement under long and equitable leases, and is truly a tenant's business, as but a small proportion of this class of rugged land occurs upon each farm.

Upon all moors (more or less) there is a certain amount of good-looking, clean, dry, and inviting land, and this is frequently ploughed down at once, just previous to winter, or otherwise in the spring, and from its clean and healthy appearance is not unfrequently sown with oats without further trouble, preface, manure, or lime. I confess that I have been amongst this class

of adventurers, but sadly to my sorrow, as I have never had or seen a good or even tolerable crop of oats growing upon a "native furrow" *without* lime. This disappointment led me to an analysis of the soil in question, and accordingly specimens were collected and sent to Mr. J. C. Nesbit for his opinion upon them, and were as quickly pronounced by him "as valueless without the aid of lime;" and he further assured me that these specimens of our natural soil (taken from below the herbage) contained but a mere trace of lime. Mr. Nesbit has kindly given me a second analysis of our "brown (dry) soil," which I now supply in his own words:—

"*Analysis of Sample of Soil, from Mr. Robert Smith, Emmett's Grange.*

	Per Cent.
Moisture	28·16
Organic matter, &c.	11·90
Siliceous matter (insoluble)	55·74
Oxide of iron and alumina, with trace of phosphoric acid	3·89
Lime	0·12
Magnesia	0·12
Soluble alkaline salts	0·07
	100·00

Nitrogen (equal to) 0·56 per cent.
Ammonia .. .. 0·68 „

J. C. NESBIT."

If an instance of the great value of agricultural chemistry was wanting, surely we have here an important case, and one which fully illustrates its general uses, but more especially in the "*testing of new soils*" BEFORE any experimental outlay of capital has been hazarded upon them in the dark. Mr. Nesbit's analysis of some soils that had been improved, and which accompanied the former (by number) without name, were exceedingly interesting and instructive as regards their newly-formed composition.

There are also extensive ranges of thin moorland, such as grow the stunted heather, English furze, and other dry-land weeds; these are lying waste from other causes—namely, want of depth and of freedom from large stones. If these wastes are situated in good climates, they *may* possibly be improved by culture and the clearing of boulder and other stones.

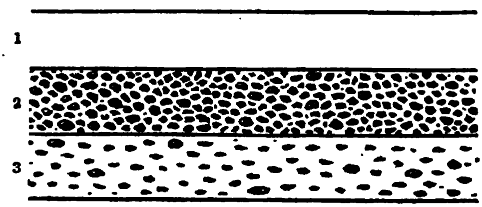
This class of soils has often (but not always) the merit of requiring but little draining, which, if it be the case, at once sets free a good amount of capital to be invested in their behalf in another direction. The difficulty is how to deepen these soils with best effect; but this is not always a necessary and least expensive process, as some lands are found to crop best after comparatively, and even after what some would think ridiculously, thin plough-

ings. As an instance the Wolds in Gloucestershire may be referred to.

Loose stones may often be converted into uses, such as the building of walls, filling in of drains, repairing of roads, &c., and are thus cleared from the land at a cheap rate; but in really stony districts they are so numerous, and their requirements for the above uses so reduced, that it becomes so formidable an affair that they are left to nature's course.

Loose stones of moderate size are sometimes found advantageous rather than otherwise, but this occurs only where warmth is required (such as many of the cold soils in Bedfordshire), as they thus act as attractors and conductors of heat to cold-bottomed lands.

I may mention a singular experiment that has been tried in the neighbourhood of Luton, Beds, by removing the surface stones from one land to another, thus:—



No. 1 had the whole of the surface stones removed and cast on to the No. 2; while the No. 3 was allowed to remain in its natural state.

Result.—No. 1 came to harvest nearly one week later than No. 3 and ten days later than No. 2.

No. 2 being about four days earlier than No. 3. In quality of grain No. 2 was best, but not quite so heavy in bulk.

No. 1 being much inferior to the others both in quantity and quality, but more especially in the latter.

These experiments being tried by a relative, I have been furnished with their ultimate decision by practice, which has been to "let nature alone:" as—

No. 1 by removing the stones became too cold;

No. 2 by receiving them became too hot; and

No. 3, in its natural way, was best.

Waste lands that have a preponderance of stones upon their surface are those that become most readily and too quickly heated by the solar rays, and thus become objectionable for the purposes of tillage lands. By deepening these soils, exposing them to continued atmospherical influences, pulverization after consolidation, changing the kinds of plants grown upon them,

and ploughing under of vegetable crops as manure, these lands may be infinitely improved, at a not very large outlay, and chiefly by the tenant.

The pulverization of soils increases their capillary attraction, and it is evident this attraction must be greatest when the particles of the earth are finely divided, for the sands and gravels hardly retain water at all; yet pulverization is of great advantage in admitting the nightly dews to the roots of plants: it is further necessary to have the land open, and to a good depth, that there may be free ingress for the air and tepid rains of spring.

When the roots of plants are deep they are less liable to be injured by excessive drought, and the space from which their nourishment is derived is more considerable than when they are superficially inserted in the soil. The soil thus deepened and pulverized may be compressed by heavy rolling, but more properly by the application of earthy matters or the treading of sheep.

As an instance that dry sandy soils can be profitably converted from the waste to culture, I have only to mention the success of the Norfolk farmers upon the Holkham and other estates of that county, as also many districts in Nottinghamshire.

A parallel case may be quoted in reference to the reclaiming of the wastes and rabbit-warrens of Lincoln Heath, a soil originally covered with heather and weeds, and in depth scarcely worthy the notice of a passer by. These were brought into cultivation by spirited occupiers and their well-directed capital, under liberal and *judicious* covenants for their unexhausted improvements, given by their landlords, the late Lord Yarborough, Mr. Chaplin, and others, and *but for which* the warren might have been a warren still.

The Fens (moorlands) of Lincolnshire, apart from the spirited outlay in their drainage, have been much improved, as have also the fen peaty lands of Cambridge, Huntingdon, &c., by means of "claying."

This *claying* operation is carried on with great success, and when first discovered and adopted was "a great move in the right direction." The operation may be shortly described as follows:—Perpendicular pits (in line) are sunk at a distance of say 14 to 15 yards apart between the rows, and on reaching the clay (which varies in depth from 3 to 6 or 10 feet), the workman "casts out" some 2 to 4 draws in length, part on each side of him, and in sinking the succeeding pit the upper black earth is thrown into the last one to fill it up, and so on; the object in sinking pits for this purpose is to prevent the sides of an open

long cut coming together, as they were accustomed to do before the plan of "pits" was adopted. Still there are many lands that are advanced in cultivation so far as to be free from "*bear's-muck*," and these are found to stand the work of open trenches, and the clay (from the settled state of the peats) is found to be much nearer the surface: the greatest obstacle being that of old roots and trees, which have to be removed from the surface of the clay bed.

In conclusion, I may add, that although the rough and rugged "Moorlands" are, from their altitude, beyond the growth of corn with profit, and in consequence unpopular in the arena of agricultural improvers, I am induced from practical experience to think and hope that the time is not far distant when we shall see even a fashion in this direction, in full competition with emigration, as a *home* paying pursuit for "stock farming."

XII.—*The Agricultural Meeting at Paris of* 1856. By J. Evelyn Denison, M.P.

In giving an account of the Agricultural Meeting at Paris of 1856, it is impossible not to speak, in the first instance, of the great beauty of the general spectacle, and its excellent arrangements both for order and effect—a happy example of the characteristic genius and taste of the nation.

It was certainly no common fortune to have such a building as the Palace of Industry ready to the hand for such an exhibition, but it was turned to account with singular skill; nothing was omitted that could add attraction to the scene. The centre area was formed into a garden stored with rare plants and flowers in full bloom, decorated with fountains, in the basins of which the artificial rearing of fish was exhibited, and enlivened by a collection of birds of rich plumage; while around, beneath the galleries, stalls were arranged for the cattle, with the names of the races inscribed, and with space for above 1000 head, all collected under one roof, kept with the most scrupulous care and neatness, and accessible in the most convenient manner to the crowd of visitors.

The exhibition consisted of *animals*, of *machinery*, and of *products*. A president of each class was appointed by the French government, with a large staff of jurors, Frenchmen and foreigners.

I have availed myself of the obliging assistance of my English colleagues, members of the different juries, who, at my request, were so good as to make notes of such objects as appeared to

them chiefly worthy of attention. For the animals, Messrs. Hudson, Milward, and Barrett; for machinery, Messrs. Amos, Caldwell, and Huskinson; for products, Sir A. Macdonald.

Cattle.

The collection under one roof, of cattle of so many various breeds, from almost all the countries of Europe, was the most remarkable feature of the show. The question will at once be asked—of all these races are there any which surpass the races of these islands, or which afford a probability of inducing improvement by crossing? The answer to that question will not increase the interest of this Report, as in both cases it must be in the negative.

The two races which looked the most suitable for our purposes were the Dutch and the Flemish (Race Hollandaise and Race Flamande).

The Dutch cows, generally black and white in colour, are large in frame and good milkers, but with an undue proportion of bone and of coarse beef.

The Flemish, red in colour and with good skins; not so coarse in the bone as the Dutch; in frame large and lengthy. No doubt both these varieties would cross advantageously with Short-horn bulls; but the proper course would seem to be for the owners of these cows to seek our bulls, rather than for us to seek their cows.

The specimens of English cattle exhibited were numerous and very good; the Short-horns occupying the first place, and attracting the chief attention of all foreign breeders. Mr. Milward informs me that some dissatisfaction was occasioned by the decisions of the jury in this class on two points:—

1. Bulls were objected to, as too old, at the age of 5½, though no limit as to age was prescribed in the programme.

2. Some cows and heifers were excluded from competition on the score of being too fat and as not likely to breed, which, it was thought by the English jurors, should not have been so condemned.

The Ayrshire cows were much liked and sought after. One of the great attractions of the show, from their novelty as well as from their excellence, were the black polled Angus. These were more uniformly good than any other class; of great size, quality, and symmetry. An extra gold medal was awarded to Mr. MacCombie for having shown so many good animals of this breed.

Among sheep, the great demand, as in the last year, was for the English Southdowns, and Mr. Webb maintained his foremost position in this class.

Some ewes of large size were exhibited from Holstein, each

with three, and some with four lambs. It might be worth while to ascertain by experiment whether the remarkable fecundity of this race could be turned by us to good account.

We regretted very much that horses were not included in the show; the more so, as the draught horses of France are excellent, and would have obtained ready purchasers from the successful exhibitors of English cattle and sheep. In this way commerce would have sprung up, and reciprocal interchange, which it is most desirable to promote, would have been established between us. I trust the French Minister of Agriculture is satisfied that this deficiency ought to be supplied, and that prizes will be given for draught horses in the show of next year.

In connection with draught horses mention should be made of the carts of France. We have something to learn on this head. The French transport immense loads on a pair of high wheels. I was assured, that in the conveyance of stone to Paris along a paved road, three horses have moved as much as nine tons. It is impossible to observe the every-day traffic of the streets and the roads, and not to see that three horses on a pair of high wheels are conveying loads exceeding the load we convey with four horses on waggons with four wheels. It is true these high wheels on straight axles elevate the loads to an inconvenient height; but it would seem possible to unite the advantage of high wheels with low loads by the use of crank axles. The power of welding iron by the steam-hammer gives increased facility for the construction of crank axles.

I beg leave to invite the special attention of the Council of the Society to this point, as one in which they may lead the way to an important improvement.

I invite the attention of our spirited machine-makers and constructors to the same object. They will, I doubt not, run before the suggestions of the Council, and not delay thus to add to the long list of services already performed by them to the cause of agriculture.

MACHINERY.

In the class of machinery Mr. Amos regrets that after a close examination he can discover but few novelties which are likely to be useful to the English farmers. He points out one novelty, in the formation of the boiler of a portable steam-engine, exhibited by Mr. E. Perignon of Pau (art. 1667). The fire-tubes of this boiler are constructed in such a manner that they can be easily removed and cleaned. This is effected by a main fire-tube being connected at one end to the front plate of the boiler, and at the other end to a wrought-iron box. The smaller tubes are fastened in a similar manner. The heat passes through the main fire-tube, and returns through the ten small tubes, and the

smoke passes up the chimney fixed at the front end of the boiler. The whole is removed by unscrewing the front plate—an operation easily performed.

A cart exhibited by Mr. Thomas Murray (art. 348) has a contrivance for easing the labour of the horse when descending hills. The body of the cart strikes upon a carriage fixed to the axletree, and two wood blocks are fastened to the front of the cart to act as breaks. When the cart is descending a hill, and the horse, by hanging back, endeavours to retard its too rapid progress, the body slides backwards, the break presses against the wheels, and a part of the load is removed from the back of the horse by the centre of gravity of the load being thrown more backward on the wheels.

In the general exhibition may be noticed a seed-extractor (art. 26), exhibited by Mr. Burwell of Thetford, which is intended for trefoil, and is a strong-made article, well adapted for the purpose.

Art. 1460, exhibited by M. Laborcy of Paris, is an excellent invention for cleaning wheat. "Red wheat" subjected to the process has the appearance of "white wheat" when it leaves the machine.

Mr. Caldwell saw nothing which suggested improvements in our existing machinery. The French threshing machines were weak in construction, and wanting in some of our best improvements. In the award the names stood thus:—

Messrs. Ransome and Sims	.. .. ..	1st Prize.
Garrett and Son .. Barrett and Exall ..	equal each	2nd Prize.
Duvoin (French)	.. ..	3rd Prize.

Mr. Huskinson reports as follows on the *ploughs*, *harrows*, *scarifiers*, and *rollers*:—

"In ploughs, the English competitors were Howard, Ransome, and Busby, all men who are most eminent in their class at home. The foreign ploughs were very numerous, but, excepting the ploughs from the Grignon establishment, and one or two from Belgium, they need no mention."

"The construction and finish of the English ploughs were superior to anything exhibited, but they were also the most costly. The conditions under which the trials took place were particularly unfavourable to the English ploughs, and the work done was less satisfactory than I ever saw at any English trial, and it was certainly disappointing and discouraging to see the slight difference there was in the work of the very best and the worst ploughs. This result was partly owing to the land experimented upon; but I am inclined to think that similar effects, perhaps in a less degree, would follow upon great part of the

French soil. The soil of the trial-field was naturally a light friable loam, in a state of fallow, or preparation for green crop, highly manured, and almost in a state of garden culture. There were no difficulties to overcome, no resistance in the soil, no turf to deposit, no stubble to invert, none of those impediments which test the merit of implements. But this is much the case, I believe, generally throughout France. The soil is naturally lighter and generally drier than in England. It is scarcely ever seeded for pasturing with stock, which increases still more its friability. In England the soil, naturally tenacious, is rendered more so by the humidity of the climate, and from the quantity of the stock kept upon it. The English ploughs have been successively improved to overcome these difficulties, which I think would prove quite insuperable to any foreign plough seen at Paris. These differences in the conditions of soil, and mode of cultivation, in England and France, have doubtless an important bearing on the implements to be used, and I concur in the opinion expressed by all my colleagues that the same implements are not equally applicable to both countries. It will be well for the English makers to give this point their serious consideration. The general form and construction of their ploughs is so superior, that, if they were divested of all the wheels and apparatus which, though necessary in England, are not required in France, the cost would be reduced, greater simplicity secured, and their use much extended. It must be obvious to all who saw the bulk of the foreign ploughs that the great demand on the continent is for a light plough, capable of being drawn in free soils by a single horse. If our best makers will turn their attention to the production of a simple, but well-formed and well-constructed plough, they need fear no competitors who exhibited at Paris."

"The distinction in the soil of the two countries did not affect the other implements. The operations of harrowing, rolling, and cleaning, are much the same in both, and here the English implements of established repute showed their great superiority, and took the first prizes in each class. Howard's harrows, Crosskill's roller, and Coleman's cultivator, had no competitors worth notice in their respective classes; but in these I would suggest that implements should be produced which are better adapted to small occupations, that being the prevailing condition through vast districts of the Continent."

Agricultural Produce.

Sir A. Macdonald reports that the collection of produce was very extensive and full of interest. His attention was chiefly directed to corn and seeds, which were delegated to his section of the jury. The principal prizes for cereals and seeds were awarded as follows:—

Collections.

1. Messrs. Lawson and Son, Edinburgh, for an admirable assortment of every kind of corn and seed cultivated in the United Kingdom.
2. The Imperial School of Grignon came next in order of merit. They displayed 127 different varieties of wheat, 20 specimens of oats, and 14 of barley, all in a growing state: these were particularly interesting.
3. The Algerian collection of corn was very remarkable; it comprised several samples of the harvest of 1856, and I observed one sample of barley, second crop.

These three collections received the great medal of honour.

After naming the awards of the other medals and prizes, Sir A. Macdonald writes,—" I am sorry to say that the agricultural products of England consisted only of a few samples of corn, all more or less indifferent, of three fleeces, one lot of potatoes, a bottle of sheep-dipping stuff, and some coprolites. The cheeses of England were not to be found in the English department, but were represented by a solitary Cheddar among the Scotch products. An Austrian gentleman asserted that his countrymen and the Bavarians were the only hop-growers in Europe. We begged him to examine our English hops, but they, like the cheeses, were not there. Neither was there a single specimen of our celebrated ales or porter in the whole exhibition, though at present there appears to be a mania for beer-drinking at Paris. It is to be hoped that at the forthcoming Concours Agricole in 1857 the English collection of agricultural produce may be more worthy of the place it holds in the French catalogue, which is the first, the post of honour. The Scotch and Irish collections of produce were as remarkable for their excellence as was the English for its mediocrity."

To these observations of Sir A. Macdonald's about the absence of English cheeses from the show may be added that 5 gold medals and 22 silver medals were awarded for cheeses, almost all of which fell to the share of the Swiss varieties of Gruyère and to a few French cheeses.

It is hoped that these short notes may be of some service to those of our countrymen who intend to exhibit in any of the classes next year, pointing out some things to be observed, and some things to be avoided, by those who desire to attend the show with credit and success.

J. Evelyn Denison.

XIII.—*Manure for Mangold Wurzel.* By JAMES CAIRD.

THERE is probably no root-crop grown by the English farmer which is more under the influence of manure than mangold. To no other green crop can a heavy dose be so safely applied, and the only question with the grower is to ascertain the kind of manure which at the least cost will produce the greatest effect. Not knowing exactly what might be the most suitable dressing for this crop, I last spring adopted the safe method of applying a mixture of all the best manures in the following liberal proportions, viz.:

15 cubic yards of good dung,	2 cwt. of superphosphate,
2 cwt. of Peruvian guano,	2 cwt. of nitrophosphate,

4 cwt. of common salt,

to each acre of my general crop on a good loam in Kent, within ten miles of London, and the result has been very satisfactory. The produce of one measured acre, probably the best in the field, weighed upwards of forty tons of roots (the yellow globe variety), and the whole field has averaged over thirty tons.

In order to ascertain which one of these manures had the best effect, I directed a series of experiments to be made in another field, where the soil was more gravelly and not quite so favourable to the mangold crop. There were twelve experiments altogether, each occupying the tenth part of an acre, each comprising three rows of roots, the middle one of which was weighed in testing the results. The whole plot was of uniform soil, the previous crop on which had been wheat after Italian rye-grass.

The experimental crop of mangold varied from 11 tons 18 cwt. up to 30 tons 12 cwt. an acre—the best acre being thus nearly three times as productive as the worst. The best and the worst are here brought together:—

The Best received

20 cubic yards of dung
4 cwt. of Peruvian guano
5 cwt. of common salt
} and produced 30 tons 12 cwt.

The Worst,

8 cwt. of superphosphate alone, and produced 11 tons 18 cwt.

It is thus clear enough that superphosphate by itself is not a good manure for mangold.

Taking the best again as the point of comparison, I compare it with

The Second Worst,

Eight cwt. of nitrophosphate alone, which produced 12 tons 11 cwt.,

and with

The Third Worst,

Five cwt. of Peruvian guano alone, which produced 12 tons 15 cwt.;

experiments which show equally clearly that neither of these manures singly will ensure a good crop of mangold.

But in case these applications had been made in too small quantities, I tried a second series with larger quantities applied singly, and embracing a comparison with dung alone, with the following results:—

	tons.	cwt.
40 cubic yards of dung produced	21	3
7½ cwt. of Peruvian guano	17	17
12 cwt. of superphosphate	14	19
12 cwt. of nitrophosphate	15	6

The best of these is nearly a third short of the best experiment, and the worst is more than one-half deficient.

The next series is a mixture of all the manures in various proportions, salt however being an additional constituent of each:—

1.

		tons.	cwt.
20 cubic yards of dung 1 cwt. of Peruvian guano 1 cwt. of superphosphate 1 cwt. of nitrophosphate 2 cwt. of common salt	produced	25	10

2.

2 cwt. of Peruvian guano 2 cwt. of superphosphate 2 cwt. of nitrophosphate 2 cwt. of common salt	"	20	6

3.

1¼ cwt. of Peruvian guano 1¼ cwt. of superphosphate 1¼ cwt. of nitrophosphate 1¼ cwt. of salt	"	19	11

In each of these cases the proportion of salt seems to have been too low, as, by running the eye down the annexed general Table of the experiments, it will clearly be seen that in every instance where salt forms an ingredient of the manure the produce is increased.

This brings me to the last of the series, though the first in the Table, which, taken with the effect of salt in all the other cases where it was applied, clearly shows that for my soil and locality SALT should form a main ingredient in any mixed manure for the mangold crop. Thus—

	tons.	cwt.
20 cubic yards of dung, and 4 cwt. of Peruvian guano, gave ..	23	16
While the same manures, with the addition of 5 cwt. of salt, gave	30	12

The additional 6 tons 16 cwt. were thus obtained at the moderate cost of 7*s.* 6*d.*, the price of 5 cwt. of salt.

The annexed Table shows the details of the whole series of experiments, with the cost of the manure and the produce of the

crop. I hope it may be found to contain some useful hints to mangold growers as to the best mixtures of manure for that crop.

Langley Park, Nov. 22, 1856.

SIR,—The enclosed experiments were carefully conducted; the dung was drawn and spread under my eye; the artificials sown with my own hand; the roots were pulled and weighed in my presence: in short they have received my best attention.

WILLIAM HORN, Farm Bailiff.

James Caird, Esq.

Experiments with different Manures on Mangold Wurzel—Crop of 1856. Sown May 21; raised Nov. 12.

No. of Lots.	Kind and Quantity of Manure per acre.	Cost per cubic yard or cwt.	Total Cost of Manure per acre. £. s. d.	Produce per acre. tons. cwt.
1	20 cubic yards of dung ..	per yard. 3s. 6d.	5 18 0	23 16
	4 cwt. guano	per cwt. 12s. 0d.		
2	20 cubic yards of dung ..	per yard. 3s. 6d.	6 5 6	30 12
	4 cwt. guano	per cwt. 12s. 0d.		
	5 „ salt	1 6		
3	20 cubic yards of dung ..	per yard. 3s. 6d.	4 18 6	25 10
	1 cwt. guano	per cwt. 12s. 0d.		
	1 „ superphosphate ..	7 0		
	1 „ nitrophosphate ..	6 6		
	2 „ salt	1 6		
4	40 cubic yards of dung ..	per yard. 3s. 6d.	7 0 0	21 3
5	2 cwt. guano	per cwt. 12s. 0d.	2 14 0	20 6
	2 „ superphosphate ..	7 0		
	2 „ nitrophosphate ..	6 6		
	2 „ salt	1 6		
6	7½ cwt. guano	12 0	4 10 0	17 17
7	12 cwt. superphosphate ..	7 0	4 4 0	14 19
8	12 cwt. nitrophosphate ..	6 6	3 18 0	15 6
9	1½ cwt. guano	12 0	1 16 0	19 11
	1½ „ superphosphate ..	7 0		
	1½ „ nitrophosphate ..	6 6		
	1½ „ salt	1 6		
10	5 cwt. guano	12 0	3 0 0	12 15
11	8 cwt. superphosphate ..	7 0	2 16 0	11 18
12	8 cwt. nitrophosphate ..	6 6	2 12 0	12 11

XIV.—*On the Cultivation of Mangold-wurtzel.* By CHARLES PAGET.

NO one can have cultivated turnips for many years, in the Midland and Eastern Counties, without discovering that notwithstanding our improved appliances, the crop has become more precarious and less abundant. Hence it is desirable to find a substitute for the swede, in feeding our cattle and sheep, which will not deprive the soil of the constituents which are necessary for the healthy growth of that root. This substitute is found in the mangold-wurtzel, or beet.

The statistical returns of agriculture show how small a space this valuable root holds in our rotations; and as I think its culture must be greatly extended when its value is properly appreciated, I will proceed to state some of its advantages, and the mode of culture which has secured for me a very satisfactory degree of success.

First then, as to the amount of produce. I can reckon upon 30 tons of beet per acre, quite as securely as upon 20 of swedes, upon good turnip land; where there is a large proportion of clay in the soil, the comparison is still more favourable to the beet. Then, the nutritive quality of the beet is, after Christmas, fully equal to that of the swede; after March it is superior.

Store cattle will thrive better upon 50 lbs. of beet in addition to their wheat straw than upon 4 lbs. of oil-cake. Suckling ewes and feeding sheep will consume 14 lbs. daily very profitably. It is, however, for the milking and feeding beasts that I find its chief value, and after January I give these animals 80 lbs. daily, in addition to their hay, chaff, and 4 or 6 lbs. of corn or cake. In the later months of the winter I give each horse in my cart-stable 8 lbs. of beet daily.

A great advantage which the beet possesses over the turnip is its early maturity. On those clayey soils in which it produces the heaviest crops, carting, in wet weather, is a very expensive and a very injurious operation; but the beet being ready for harvesting in the second week of October, it may generally be got home without injury to the land. I have, this 27th of October, secured upwards of 800 loads from 22 acres, and left the land, with the tops scattered over it, in good order to be ploughed for wheat; and it is very seldom that we have experienced a wetter October. Notwithstanding the large produce derived from this crop, the succeeding wheat or barley will generally be very good, if the tops are equally distributed over the land and ploughed in. For many years I have had an average of 6 quarters of wheat to the

acre in this part of my rotation, without any other dressing than 3 cwt. of salt.

The beet sends down its feeders deep into the marly subsoil. I am now engaged in carrying a drain, 4 feet deep, through part of the field on which it grew this year, in order to drain another part. I find the marl, 4 feet from the surface, full of small roots, and I have never seen a full crop where the subsoil was unpropitious, as, for instance, on a poor, sandy or gravelly subsoil; but beet will derive sustenance from many tenacious clays if they are well drained.

This property of sending its roots to a great depth in the subsoil has its inconveniences. I have seen many drains 4 and even 5 feet deep, choked by the roots. This will only happen where there is a summer run of water, and in these situations I recommend the substitution of cabbages or potatoes near the drain—say for 6 feet on each side of it. The greater part of my arable land only requires drains to carry off the excess of rain-water in very wet weather, and was effectually drained, more than thirty years ago, with tiles from 24 to 30 inches deep. On this land I never see any mischief from the roots of the beet, which penetrate far below the drains into the subsoil.

On the few acres on which this system of draining has not been effectual, I find that the plants become stunted and the leaves turn prematurely yellow, if a continued rain raises the water-table too near to the surface and drowns the rootlets. Such an appearance is an imperative hint to take up the tile and put it in at a greater depth.

The best soil for beet being somewhat tenacious, its cultivation requires peculiar care to secure a proper seed-bed. My rotation is as follows:—1st year, swedes or beet; 2nd, wheat or oats; 3rd, clover; 4th, wheat; 5th, beet; 6th, wheat; 7th, beans; 8th, wheat. If there is any couch-grass in the land, it will be easily seen after the first mowing of clover. If a man can dig it out of half an acre a-day, let him do it with a strong fork.

If there is much couch-grass, as soon as possible after the first crop of clover is mown break up the clover brush with a strong grubber, such as the Ducie drag, to the depth of at least 5 inches, and there will be plenty of time to clean it thoroughly before the wheat is sown.

Keep the wheat well horse-hoed, and in the autumn dig out any couch-grass which may remain. Then skim the ground not more than 2 inches deep, and harrow it in the driest weather.

It is now ready for the manure, of which I give 21 horse-loads to the acre direct from the fold-yard at the earliest opportunity after wheat-sowing is concluded.

I spread at the same time 10 cwt. of woollen waste to the acre. This mixture is covered in, when it will do well, by a 6-inch furrow—followed by a subsoil plough stirring the subsoil another 6 inches; this operation ought to be completed before the end of February.

If any of those circumstances which will sometimes derange the operations of the farmer have prevented his spreading his manure, so as to get it ploughed in before the end of February, and if the surface soil is in a good state, let him sow 2 cwt. of guano broadcast, when he harrows the land to prepare for the drill, and 2 cwt. more at each of the 2 first hoeings; and he will, if his fortune equals mine, find a very satisfactory crop of beet, followed by a very good wheat crop and excellent seeds.

The seed-bed ought to be in such a state that the capillary attraction will supply the seed with sufficient moisture.

This condition cannot be secured on tenacious soils, unless they are reduced by frost, so that the earth is finely divided, and consequently its parts are in contact with each other.

About March 20th harrow the land, and, if sufficient reduction of the soil has not been effected by frost, roll it and harrow again till it is fine.

The best seed-time in this locality is, in my opinion, from April 7th to April 10th. It is useless in general to sow it earlier, because the temperature is, I think, too low for the germination of the seed.

My experiments do not lead me to believe that this comparatively early sowing produces many more runners, and our summers are too short to admit any unnecessary delay in sowing. The seed should not be buried more than three-quarters of an inch. If the weight of the drill-coulter would put it in at a greater depth I employ counteracting weights, working over pullies fixed on a wooden rail, with great advantage. If the soil will not bed well to the seed and keep it moist, do not hesitate to roll and harrow after sowing. I have seen the earliest and best plant in the field on the track of a cart-wheel which had passed over it in leading off a ton of gathered pebbles. At the time of sowing give 1 cwt. of guano to the acre, and a 2nd and 3rd cwt. at the first and second horse-hoeing. My rows are drilled on the flat 24 inches apart; I endeavour to set the plants 16 inches in the row. After the second horse-hoeing I put two light horses into a grubber with five tines, and stir the soil to the depth of 6 inches. This should be done as soon as the plant is well established, lest it should break the surface roots too much; but done at the proper time it is very beneficial in promoting the rapid growth of the beet. I give 7*s.* per acre for singling the plants and giving them an

effectual second hoeing. When, towards the end of June, the leaves are too large to admit the horse-hoe, I generally give a third hoeing at 3*s.* per acre, which leaves the field sufficiently clean. If there are any material vacancies in the rows I fill them up late in May with turnips, which are sufficiently forward to be got up early in October at the same time as the beet. Let nothing induce the grower to strip the leaves from the plant before taking up the root; a series of careful experiments has convinced me that by so doing we borrow food at a most usurious interest. As soon as may be after October the 4th, I get the beet up, cutting off the leaves, but leaving the neck so that it may put out young leaves. If the neck is entirely cut off the root is apt to decay. The strong roots are cut off and the dirt removed without cutting the outer skin much. A pit is prepared by removing the soil 18 inches deep and 9 feet wide; the roots are piled about 6 feet high in the centre, and covered down with stubble and mould about 10 inches thick, leaving apertures every 20 feet at the top of the pit for the escape of the heat, which, to a slight degree, is always generated in the pits. These apertures should be covered with mould when the severe frosts set in. The only insect whose attacks upon the young plant are to be dreaded is the slug. It feeds upon the seed-leaves at an early age, and, if permitted to go on unmolested, will make serious inroads, but it is easily detected by the appearance of the plant, one seed-leaf being frequently taken and the other left. The slug is at once destroyed and the crop benefited by sowing at early dawn, after a still dewy night, a mixture of 1 cwt. of guano and 2 cwt. of salt to the acre.

As to the kind of beet to be sown, my experience leads to the conclusion, that, upon very good land in a fine warm summer, a larger crop may be obtained from the long red than from the orange globe, but the latter is the hardier plant; in cold springs it germinates more freely, and I have now adopted it exclusively for my main crop.

My experience of the value of this root has been so long and so uniform that I have no hesitation in calling upon my brother farmers, who are similarly situated as to their climate and their soil, to participate in its advantages.

Ruddington Grange, near Nottingham.

XV.—*On the Action of the Atmosphere upon newly-deepened Soil.* By THOMAS F. JAMIESON, Ellon, Aberdeenshire.

PRIZE ESSAY.

SOIL or earth newly turned up to the surface is exposed to many influences which before affected it either not at all or only in a faint degree. These influences mainly arise from the atmospheric envelope surrounding our planet, and from the rays of that luminary whose powerful attraction guides it in its path through space.

But besides this exposure, the soil is also thus released from pressure, and has full freedom to expand, crumble down, and spread itself out to the enriching effects of the sun and air, and to inhale freely the breezes which play around it, bringing materials which are as necessary for its amelioration and changes as they are to the living organisms that exist upon its surface.

The subject, therefore, naturally divides itself into these two branches:—

1. The *solar* influences, embracing the effects of temperature and light.
2. The *aërial* influences, or those arising from that mixture of substances which forms our atmosphere.

It is proposed, therefore, first to take into consideration the action of the sun's rays, then to pass on to the effects produced by the several constituents of the atmosphere, and after that to look somewhat into the ingredients of the soil with the view of showing how they are likely to be affected by those agencies which will have come under our notice. In this manner, it is conceived, opportunities will be afforded of touching upon all those topics which this paper should embrace.

First, then, as to the influences emanating from the sun. The sunbeams which play upon our globe have a more complicated action than was of old supposed. Newton, transmitting one of these beams through a glass prism, found the resulting spectrum to be composed of the seven rays, red, orange, yellow, green, blue, indigo, and violet; which Brewster would simplify into three, Red, Yellow, and Blue, and their modifications. Attention being thus directed to the compound nature of the solar radiations, it was soon observed that they possessed different properties, and it is now found that they have at least four well-marked characteristics:—

1. The calorific, or power of imparting heat.
2. The luminous, or power of imparting light.
3. The chemical, or power of inducing chemical changes.

4. The phosphorogenic, or power of inducing phosphorescence.

Other properties, for aught we know, may be induced, such as magnetism, and perhaps more not yet investigated.

"If we decompose," says Melloni, "a bundle of solar rays by means of a rock-salt prism, and measure the degree of heat proper to each band of the spectrum, we find that the temperature increases from the violet towards the red until it has reached a point midway between the red and the yellow; at this point a pretty rapid decrease of temperature takes place." Light and heat, he concludes, proceed from two distinct causes which, perhaps, are but different effects of a single cause—the luminous and the calorific rays being perhaps only two essentially distinct modifications which the etherial fluid suffers in its mode of existence.

Of these properties, the power of imparting heat is the one that most powerfully affects the materials of the soil, and as the effects produced are mainly due to the alternations of heat and cold brought about by the vicissitudes of day and night, summer and winter, it will be necessary to investigate what are the conditions of temperature to which the soil is exposed both at the surface and at moderate depths.

Professor J. D. Forbes has shown (*Proceedings of Royal Society*, iv. 391) that the solar rays are subject to considerable diminution in their passage through the atmosphere. The law of the absorption of the incident heat rays probably depends on a difference in their nature, their elements being partly absorbable and partly persistent, the absorption in passing through a vertical atmosphere of 760 millimètres of mercury (=30·4 Eng. inches) being such as to reduce the incident heat from 1 to 0·534.

The amount of absorption of incident solar heat traversing the atmosphere *vertically* in clear weather is, according to—

Bouguer	19·	per cent. of that incident on the exterior of the atmosphere.	
Lambert	41·	ditto	ditto
Leslie	25·	ditto	ditto
Kämtz	32·	ditto	ditto
Pouillet	25·	ditto	ditto
Kämtz and Forbes	29·	ditto	ditto

Taking the loss of radiant heat in its vertical passage through the air at only 25 per cent., at an angle of elevation of 25° the force of the sun's heat would be reduced to one-half, and at 5° to one twentieth part. The difference of the direct effect of a vertical and horizontal sun is due to this cause alone, exaggerated immensely by the variable meteorological state of the atmosphere. (*Forbes, Brit. Assoc. Report for* 1840.)

Reaching therefore the crust of the earth, the force of the sun's rays will vary according to the exposure of the surface; if its inclination be such that the rays strike perpendicularly upon it, then the soil will be twice as much heated as it would be were the same amount of sunshine, by coming obliquely upon it, spread over double the surface. Much also will depend upon the colour of the soil, for it has been clearly proved that, for surfaces of the same texture, the heating effect of the sun's rays is in proportion to the darkness of the colour; this may be shown in a simple manner by placing differently coloured pieces of cloth on the snow exposed to the sun, when the darkest bits will be seen to sink fastest.

The ground, being generally of a dark colour, may, if dry, be expected to attain, when the sun beats upon it, a temperature similar to what a thermometer with a blackened bulb would under similar exposure. Let us see, therefore, what that may be.

Saussure, by properly defending the thermometer from wind and common radiation, raised the temperature, in the sun, to 190° F. Pouillet also states that he found the thermometer, properly protected and exposed perpendicularly to the solar rays, assume considerable elevations, often rising 90° F. above the ambient temperature towards noon; it sometimes even rose to 194° F., the temperature of the air being 80°.6 F., showing an elevation in this case of 113°.4 F.; and as the result of his observations he found that the thermometer exposed to the sun may, according to the dispositions given it, take any required excess above the temperature of the air from 5° F. up to 115° F. (*Scientific Memoirs*, vol. iv., pt. 13, p. 90.) Even at Edinburgh in July Mr. Foggo obtained by means of a large thermometer having the ball covered by dark wool and fully exposed to the direct rays of the sun, unsheltered from the wind, a temperature of 150°.

We may therefore expect that in calm, clear, summer weather the surface of the ground will attain a very high degree of heat, and that this will especially be the case under a vertical sun. In Nubia, "under a hot and copper sky," the Arabs say the soil is like fire. Sir John Herschel, on the 5th of December, 1837, between one and two P.M., observed the heat under the soil of his bulb-garden at the Cape of Good Hope to be 159° F., at 3 P.M. it was 150°, the temperature of the air in the shade in the garden at the same time being 98° and 92°. (Quoted by Lindley in his *Principles of Horticulture*, p. 125.)

Observations are much wanted to show what temperature the surface soil attains in this country. Mr. Whitley, of Truro, so late in the season as the 16th of September, the air in the shade

being 65°, ascertained that the temperature of the upper two inches of garden-mould exposed to the sun's rays was 84°, at four inches deep 69°. But the thermometer in the shade, as I shall afterwards show, has been noticed in England as high as 96° F.; the soil therefore must occasionally attain a heat almost approaching to that observed by Herschel.

This heat will be affected to a considerable degree by the condition of the soil as to dryness, the evaporation of any moisture it may contain reducing the temperature considerably; this depression, according to Schubler, amounts to 11¼° or 13½° F. Schubler made some of the most careful investigations we possess as to the warming of soils by the sun. With surfaces of the same colour he found that the materials composing the soil made little difference in its capacity to become heated, provided they were in similar states as to dryness; sand, clay, loam, garden-mould, &c., showing very little difference with the thermometer. Colour, however, had a powerful effect; for the communication of a dark tint he employed lamp-black, and for white fine magnesia, sprinkling these over the surface by means of a fine lawn sieve. Although exposed to the sun for hours, the differently coloured earths never attained the same temperature, the lighter coloured always remaining considerably cooler. The following are some of his results:—

Kinds of Earth exposed to the Sun's rays between 11 and 3 o'clock in the latter part of August: temperature in the shade 72½° to 77° Fahr.	Mean of the highest Temperature of the surface of the Earths in the shade, 77° Fahr.			
	Surface of Natural Colour.		With Dry Earth.	
	Wet.	Dry.	With a White Surface.	With a Black Surface.
	°	°	°	°
Siliceous sand—bright yellowish grey	99·1	112·6	109·9	123·6
Calcareous sand—whitish grey	99·3	112·1	109·9	124·0
Sandy clay—yellowish	98·2	111·4	108·3	121·6
Loamy clay—yellowish	99·1	112·1	107·8	121·1
Stiff clay—yellowish grey	99·3	112·3	107·4	120·4
Fine bluish-grey clay	99·5	113·0	106·3	120·0
Garden mould—blackish grey	99·5	113·5	108·3	122·5
Arable soil—grey	97·7	111·7	107·6	122·0
Slaty marl—brownish red	101·8	115·3	108·3	123·4

The earths were placed in vessels with four square inches of surface and half an inch deep, thermometers being placed in them so as to have their bulbs covered one-eighth of an inch high with earth.

Sir H. Davy says, "I found that a rich black mould, which contained one-fourth of vegetable matter, had its temperature

increased in an hour from 65° to 88° by exposure to sunshine, whilst a chalk soil was heated only to 69° under the same circumstances." The mould, however, was found to cool much quicker than the chalk. A brown fertile soil he also noticed to cool quicker than a cold barren clay, but when the clay contained moisture it lost its heat very rapidly.

In the following table I have thrown together some of the highest temperatures which the soil has been observed to take, premising that good observations of this kind are scanty, and that considerably greater degrees of heat must occur in tropical climates:—

Places.	Shade, Temp. of the Air.	Temperature of the surface Soil.	Authority.
	°	°	
France	91·5 F.	127 F.	Arago.
Geneva, 1334 Eng. feet above sea	..	125	Schubler.
Tubingen, 1076 Eng. feet do. ..	78·0	153.5	"
Egypt	..	144	Edwards and Colin.
Tropics	..	often 126° to 134°	Humboldt.
Oronoco, coarse white sand ..	84·5	140	"
African Desert, sand..	..	140	Dr. E. Vogel.
Nubia, sand	..	150	Thompson's Meteorology.
Cape of Good Hope, soil of a garden	98·0	159	Sir J. Herschel.
Bermuda	..	142	Col. Emmett.

The following is a valuable table of observations made by Schubler, with regard to which he remarks: "Those observations

Months.	In perfectly fine Weather.			In Variable Weather: Mean of the whole Month.			
	Mean Temperature of the		Elevation of Temperature by the Sun's rays, in Degrees.	Mean Temperature.			
	Earth's Surface.	Air in Shade.		Of the Earth's Surface at Noon.	At 3 inches below the Soil.	At 4 feet below the Soil.	Of the Air in the Shade.
	°	°	°	°	°	°	°
January ..	54·1	24·6	29·5	43·0	38·5	39·4	38·2
February ..	86·2	43·0	43·2	45·7	39·8	38·6	36·8
March ..	99·5	46·6	52·9	53·2	43·2	38·1	38·1
April ..	121·6	61·7	59·9	78·9	60·7	48·3	50·1
May	131·2	67·3	63·9	80·1	64·4	54·6	55·9
June ..	139·8	75·2	64·6	89·1	73·6	61·5	60·9
July ..	146·3	81·3	65·0	93·4	73·3	64·9	63·2
August ..	130·1	68·9	61·2	96·0	76·9	68·6	65·8
September	119·8	68·0	51·8	82·8	70·2	66·1	62·4
October ..	80·8	42·8	38·0	59·8	54·4	58·8	51·8
November	72·7	40·1	32·6	47·3	43·7	49·0	41·6
December	59·2	35·6	23·6	35·3	33·3	39·0	32·1
Means ..	103·4	54·6	48·8	67·1	56·0	52·3	49·7

which are marked as having been made in fine weather exhibit the mean highest temperature of an ordinary blackish-grey garden mould, as observed on the south side of my house between noon and one o'clock, whenever the weather happened to be perfectly fine at that part of the day. They are founded on the average of two years' observations; the bulb of the thermometer was covered only $\frac{1}{12}$ of an inch high with earth. Those figures in the table which refer to variable weather rest on observations made in the Botanic Garden at Geneva in the year 1796; they contain the mean of the observations made every day, and not merely of those taken in fine weather."

The above observations will serve in some degree to show to what a high degree of warmth the surface-soil will attain under a clear sun, even where the temperature of the air in the shade is similar to what frequently occurs in this country. Under such a degree of heat the decomposition of the organic matter of the soil must go on at a great rate, with the evolution of much ammonia and carbonic acid, agents which, as will be afterwards shown, play an important part in the modifications of the mineral matter of the soil. It may be also gathered from the last table what elevations of temperature the surface of the ground may be expected to attain above that of the air in the shade, as usually recorded in meteorological registers. It will be observed also that in one case, at Tubingen, the soil rose 75° above that of the air, when the latter was at 78° F. Bearing this in mind, and glancing over the shade temperatures which will be found subjoined, the conclusion, I think, cannot be avoided that in some countries the ground must attain a degree of heat much above any yet recorded, perhaps occasionally approaching 200° F.

	Temperature of Air in the Shade.	Authority.
	° Fahr.	
Near Maidstone, in Kent; 7 June, 1846	94·	G. H. Fielding, Proceed. of Royal Soc., v. 625.
Clapham; July, 1808	96·	Cavendish, Reg. of Royal Soc.
? Buckinghamshire; July, 1825	96·	Dr. Heberden, Proceed. of Royal Soc., ii. 260.
Esne, in Upper Egypt	117·5	Burckhardt.
Near the Euphrates, in the Desert	132·	Griffiths, Travels in Arabia.
Salt Lake of Bahr Assal	126·	Harris, Highlands of Ethiopia.
Arabia	120·	Encyc. Brit., 8th ed., iii. 737.
Nubia	130·	Thompson's Meteorology, p. 56.
Northern Circars, India; *at midnight* in 1799	108·	Ditto, p. 55.

The following table shows some of the greatest degrees of natural cold that have been observed in this and other countries:—

	Temperature of Air in the Shade.	Authority.
	° Fahr.	
Ellon, Aberdeenshire; 20 feet above sea-level, and 5 miles inland; 17 Feb., 1855	−12·	The writer.
Glasgow; 14 Jan., 1780, at 6 A.M.	−14·	Dr. Wilson, Phil. Trans., 1780.
Rothiemurcus, Inverness, Feb., 1823	−15·	Ed. Phil. Journ., viii. 396.
Strachan, Kincardineshire; 200 feet above sea-level, and 15 miles inland; 17 Feb., 1855 ..	−15·	Rev. A. M'Connochie in a letter to the writer. Temperature was three times below zero in this same month.
Siberia, lat. 58°	−40·	Pallas.
Melville Island	−55·	Sir W. E. Parry.
Nova Zembla	−38·7	Encyc. Brit., 8th ed., iii. 737.
On the Kolyma, in Asia, lat. 68° 32′; 8 Jan., 1821	−58·3	Ditto, stated to be greatest cold in Asia.
Arctic regions of North America, lat. 65°	−57·	Sir J. Franklin.
Fort Reliance	−70·	Capt. Back, Travels in Arctic Regions, p. 631.
Head of Smith's Sound, Arctic regions of North America; Feb., 1851	−70·	Dr. Kane, of the U. S. Navy. Chloric ether froze, and 57 dogs perished under symptoms of hydrophobia.

Pouillet calculates that if the sun's action were not felt upon our globe, the temperature of the surface of the ground would throughout be uniform at −128° F.

As the disintegrating effects of temperature are due principally to frost and the variations or range of heat to which the earth is exposed, it is necessary to look even more closely at the degrees of cold to which the soil may be subject than we have done to the amount of heat. This we shall find is often many degrees lower than the temperature of the air a few feet above it; knowing, however, what that is likely to be, we shall be the better able to judge how low the temperature of the soil may be liable to fall, as few meteorological observations are recorded concerning the latter.

The following Table (p. 414) shows the extreme heat and cold and range of the thermometer in the shade at various places on the earth's surface.

From the effects of radiation and evaporation, the surface-soil is often many degrees colder than the atmosphere at the height thermometers are usually hung (4 to 5 feet), and this is the case even in winter. Thus Dr. Patrick Wilson, of Glasgow, during the severe frost of January, 1780, found in the declivity of a garden, during a clear starlight night, a thermometer laid on the surface of the snow stood from 8° to 10° lower than when suspended at the height of a few inches.

	Maximum.	Minimum.	Range.	Authority.
	°	°	°	
Alford, Aberdeenshire lat. 57° 13′ N.	84·0	-12·0	96·0	Rev. Dr. Farquharson, 420 feet above sea; 26 miles inland; 15 years' observation.
Strachan, Kincardineshire	89·0	-15·0	104·0	Rev. A. M'Connochie, 1850-55 inclusive.
Great Britain	96·0	-15·0	111·0	Dr. Heberden, max.; Rev. A. M'Connochie, min.
Surinam lat. 5° 38′ N.	90·1	70·3	19·8	Humboldt for max.
Pondicherry 11 42 N.	112·4	70·8	41·6	Le Gentil and Cossigny.
Madras .. 13 45 ,,	104·0	63·1	40·9	Roxburgh for max.
Martinique 14 35 ,,	95·0	62·7	32·3	Chanvalon.
Cairo .. .. 30 2 ,,	104·3	48·3	56·0	Coutelle and Niebuhr.
Bagdad .. 33 21 ,,	122·0	23·0	99·0	Encyc. Brit. and Beauchamp.
Rome .. 41 54 ,,	100·4	21·4	79·0	Schouw.
Cambridge, Massachusetts, lat. 42° 25′ N.	92·3	-11·9	104·2	Williams.
Padua .. 43 18 ,,	97·3	4·0	93·3	Toaldo.
Nice .. .. 43 42 ,,	92·1	14·8	77·3	Schouw.
Pisa .. .. 43 43 ,,	102·9	20·7	82·2	Ditto.
Lucca .. 43 51 ,,	100·5	16·0	84·5	Ditto.
Bologna .. 44 30 ,,	98·7	1·6	97·1	Ditto.
Turin .. 45 4 ,,	98·4	0·0	98·4	Ditto.
Milan .. 45 28 ,,	93·9	5·0	88·9	Observatory.
Paris .. .. 48 50 ,,	101·1	-9·5	110·6	Arago.
Prague .. 50 5 ,,	95·7	-17·5	113·2	Strnadt.
Copenhagen 55 41 ,,	92·6	0·0	92·6	Bugge.
Moscow .. 55 45 ,,	89·6	-37·8	127·4	Stritter.
Stockholm 59 20 ,,	93·9	-16·4	110·3	Ronnow and Nicander.
Petersburg 59 56 ,,	92·1	-29·2	121·3	Euler.
Extremes of the globe ..	132·0	-70·0	202·0	Griffiths, max.; Back & Kane, min.

N.B.—The degrees are of Fahrenheit's scale.

One evening in January, 1856, I made some observations of this sort in an open plot of ground in my garden. The following memorandum shows the comparative heights, at the same time, of two thermometers, one hung in a stand in the open air at 4½ feet from the ground, the other placed directly on the surface of the snow:—

Times of Observation.	Thermometer in the Air.	Thermometer on the Snow.	Difference.
	°	°	°
At 4 hours 15 minutes P.M.	32·1 F.	18·8	13·3
At 20 minutes past 4 P.M.	31·9	18·5	13·4
At half past 4 P.M.	31·3	18·2	13·1

Showing a difference in one case of nearly 13½° Fahr. The thermometers used were superior instruments made by Negretti and Zambra, of London, and had been compared with standards

at Kew Observatory. As the sky was not all clear, a greater difference would doubtless be observable under more favourable circumstances.

Mr. Six, of Canterbury, also found the thermometer, which had been suspended in the air on a clear still night in winter, fall 13½° when placed flat on a meadow; and Scoresby and Capt. Parry observed analogous depressions in the Polar regions when the temperature of the air was more than 20° below zero. Wells noticed a difference of two thermometers, one in the air the other placed in swan's-down (a good radiating substance), amounting to 15° F. (*Brit. Assoc. Report*, 1840, p. 65.)

M. Pouillet, from observations made in clear nights in April, May, and June, with thermometers placed in swan's-down, found the difference arising from radiation to be from about 10° F. to 16° F. below the temperature of the air at 4 feet from the ground; the greatest difference noticed being 16°.2 F. on the 5th May, between eight and nine in the evening. The temperature lowered gradually during the night till it attained its minimum towards sunrise. The thermometer so exposed to radiation fell frequently below the freezing point of water during these observations, whereas the one hung in the air never was below 32° F. (*Scientific Memoirs*, vol. iv. part 13, 1844.) With regard to the radiation of heat by the earth to air, Prof. Marcet has arrived at the following conclusions:—

1. It is a constant phenomenon about the time of sunset, except in the case of violent winds.
2. It attains its maximum immediately after sunset.
3. It is most conspicuous when the ground is covered with snow.

In the Andes, Darwin observed that where the rock was covered during the greater part of the year with snow, it was shivered in a very extraordinary manner into small angular fragments. And this lowering of the temperature of the ground does not occur merely on still clear nights, but also, as I have repeatedly observed, takes place by evaporation in windy weather. Thus in December, 1855, during very windy weather from the south-east, when the register thermometer did not fall below 34°.3 F., all the puddles and wet mud on the roads were frozen hard, the sky being cloudy. The amount of cold due to evaporation is often very considerable. Thus at Southampton, on 19th April, 1854, at 3 P.M., Mr. Drew observed a difference of 16° between the readings of the wet and dry bulb thermometers, the one being 69° and the other 53°. A nearly equal difference was noticed by Kämtz on the summit of the Faulhorn, the dry bulb being at 47° F. and the wet at 32°. At Geneva, in August, 1832, Prof.

J. Forbes found a coolness by evaporation, amounting to 20° F., the thermometer in the shade being at 92°; and Baron Humboldt, in his journey in Asia, noticed a difference from the same cause, amounting to 21° F., the temperature of the air being 74°.6. (*Brit. Assoc. Report*, 1832, p. 243.) The alternations of temperature, therefore, to which the surface-soil is exposed are much greater than would at first sight appear. Even in this country, from 150° in the sun to 15° below zero in the shade, we have an occasional range of 165° F., being from 118° above the freezing point of water to 46° below it.

The following table by Mr. Robert Thompson gives the average results of daily observations at Chiswick, near London, from 1826 to 1853:—

Months.	Average lowest Temperature at Night.	Average highest Shade Temperature in the Day.	Average Daily range of Temperature in the Shade.
	°	°	°
January	30·78	42·59	11·81
February	32·42	45·83	13·40
March	33·72	50·74	17·01
April	36·89	57·42	20·53
May	42·90	64·79	21·89
June	49·16	71·86	22·70
July	51·98	74·36	22·38
August	51·01	73·04	22·03
September ..	46·64	67·33	20·69
October	41·36	58·76	17·40
November ..	36·22	49·93	13·71
December ..	33·95	45·33	11·37
Year	40·59	58·50	17·91

In India the thermometer is said occasionally to range from nearly zero, before sunrise, to 130° F. at noon. (*Thompson's Meteorology*, p. 55.)

Such being the case with the surface, let us now see what takes place below, that we may compare the conditions of the top soil with those of that which lies dead beneath the plough furrow.

To assist us here we have a very valuable set of observations taken under the direction of Leslie, at Abbotshall, the seat of Mr. Ferguson of Raith, about 50 feet above the sea level, and near a mile from the shore of Kirkaldy, in Scotland, during 1815, 1816, and 1817. The details will be found in Leslie's article on Climate, in the 'Encyclopedia Britannica.' Four thermometers constructed for the purpose with long stems were sunk beside each other at the depths of 1, 2, 4, and 8 feet, in a soft gravelly soil, which turned at 4 feet below the surface into quicksand, or a bed of sand and water. It was found that during

these three years the frost did not penetrate 1 foot into the ground. The thermometer at that depth fell to 33° F. on the 30th of Dec. 1815, and remained at the same point till the 12th of Feb. 1816, but in the ensuing year it did not fall below 34°.

Here is a summary of the results in a tabular form:—

Depth of Thermometer.	Maximum Temperature during 3 Years.	Minimum Temperature during 3 Years.	Range during 3 Years.
	° Fahr.	°	°
1 foot ..	58·	33·	25·
2 feet ..	56·	36·	20·
4 feet ..	54·	39·	15·
8 feet ..	51·5	42·	9·5

Leslie also states that in the neighbourhood of Edinburgh, after a long tract of rigorous weather, the frost was found to have penetrated 13 inches into the ground in a ploughed field, but only 8 inches in one piece of pasture ground, and 4 inches in another.

Professor J. Forbes of Edinburgh found the annual range of temperature at 3 French feet (= 3·2 English feet) below the surface of the soil to vary in different strata as follows, being a mean of three years:—

	°
In trap tufa	17·41 Fahr.
„ loose sand	19·85
„ compact sandstone ..	17·41

(*Brit. Assoc. Report*, 1840, p. 73.)

M. Quetelet, director of the observatory at Brussels, made from 1834 to 1839 some observations on the range of thermometers buried in the ground at different depths. The ranges recorded by him as found at Brussels from 1834 to 1837 were:—

Depth in English Feet and Inches. Feet.	Inches.	Annual Range in Degrees Fahr.
0	7½	23·90
1	6	22·39
2	6	20·43
3	3	19·04
6	5	13·66
12	10	8·08
25	7	2·03

As to the earth, viewing the subject generally, diurnal variations of temperature are considered not to extend to a greater depth than about 3 feet, and annual variations are inferred to cease at from 65 to 70 or 80 feet.

Some valuable results are exhibited in the Greenwich Observations for 1847 with regard to the range of heat at different distances below the earth's surface. The following table shows the mean monthly reading and mean daily range of two thermo-

meters whose bulbs are sunk, one at the depth of 1 inch below the soil, the other at the depth of 3·2 feet (being 3 French feet):—

	Thermometer sunk 1 inch.		Thermometer sunk 3·2 feet.	
	Mean Monthly Reading.	Mean Daily Range.	Mean Monthly Reading.	Mean Daily Range.
January	37·9	4·1	39·3	0·4
February ..	38·0	4·4	39·6	0·3
March	42·3	7·0	41·1	0·3
April	46·4	6·9	44·4	0·3
May	56·7	9·4	51·2	0·4
June	59·8	8·1	57·2	0·4
July	66·8	10·1	61·5	0·5
August	63·9	9·7	62·3	0·4
September ..	56·0	7·4	57·9	0·3
October	53·7	5·9	54·7	0·3
November ..	48·4	5·0	50·6	0·3
December ..	44·0	4·5	46·4	0·3

A comparison of this last column, where the average daily range is reduced to less than half a degree, with the column of average daily range of temperature of the air in the shade, as observed at Chiswick (p. 10), where it is seen to be generally above 20°, will give some idea of the widely different conditions of the subsoil and the surface as to conditions of temperature.

Josiah Parkes, in his observations on the Red Moss, Lancashire, found that its temperature from 12 inches beneath the surface, down to the bottom, was uniformly 46° F. "I never," says he, "found any variation to occur in the results afforded by thermometers placed at various depths during nearly three years' observations, except in the winter of 1836, when the thermometer nearest the surface sunk to 44° F. for a few days." The depth of this bog, at the spot where the observations were taken, was nearly 30 feet, and there were no springs in it. (*Eng. Agricult. Journal*, vol. v. p. 140.)

From the statements given it is evident that the *surface* of the ground, even in this climate, must be subject to a range of temperature of which the recorded observations of thermometers hung in the usual manner give little conception. A comparison of the daily readings of the wet bulb thermometer, with those of one hung in the sun with the ball blackened, would give a better idea of the daily variation. But the ground at a foot deep in this country appears to be scarcely affected by frost, unless where it has been loosened up by the plough or spade.

The action of frost upon the raw mineral matter constituting newly exposed soil is of the utmost importance. This mineral matter consists of the débris of the various rocks which are found

in the country, and is in fact an aggregation of minute crystals and earthy matter; in each pebble and fragment of undecomposed stone these crystals are interlaced in all directions. Bodies of this nature exposed to the air and moisture absorb water, which enters into the interstices and crevices between the faces of these crystals, or into the pores of the raw clots of earth; should frost then take place, this contained water changes into ice, and in so doing, by a well-known law, expands with irresistible force, shivering the substance in which it is lodged into a number of particles, which number is measured by the quantity of crevices or pores into which the moisture and frost have penetrated: so long as the frost lasts these particles are all bound together by the enveloping ice, but immediately when thaw comes they separate and fall down; then the lump which before showed but one surface to the air has now a multitude of surfaces, and the atmosphere acts upon it in an infinitely multiplied degree. It will be shown that the property of condensing some important gases within a porous body is in proportion to the extent of superficies that the gas can meet with: the comminution or crumbling down of the particles of the soil is therefore, even in this respect alone, an important feature; the earthy salts of the soil are also thereby more extensively exposed to the action of the atmospheric influences in bringing about beneficial changes in their constitution. The practical importance of this is well known to farmers, who, in preparing their stubbles for the next season's crop of turnips, or such-like roots, always endeavour to get as great a breadth of land well turned over before the month of December as they possibly can, in order that it may get the full benefit of the winter's frost.

In clear keen weather during the winter months, when the thermometer in the shade may be oscillating between 30° and 40°, the skin of the soil, where it is not much covered with snow, will undergo the alternation of frost and thaw almost every four-and-twenty hours; for although the register thermometer may show only a minimum of say 35°, or 3° above freezing, yet from the effects of radiation and evaporation the soil will probably fall during the night to at least 30°, or 2° below it; and although the maximum air-temperature in the shade may not rise above the freezing point all day, yet the surface of the ground, exposed freely to the effect of any sunshine there may be, will rarely be unaffected by thaw to a greater or less depth. The effect of a thin covering of snow will be, as has been shown, to cause in clear still nights a very intense degree of frost, by reason of radiation, even when the thermometer in the air may be hovering about 32° F.: the more intense the frost the deeper it will penetrate, and the greater will be the disintegration.

In Siberia ice is found even at a depth of from 300 to 400 feet. Some experiments by M. Middendorf, as reported to the Academy of Sciences at St. Petersburg in 1844, showed that in a shaft and the galleries of some works near the Lena, at a depth of 384 English feet, the frozen crust was still not passed through, though a gradual increase of temperature was observed in the descent. In the same latitude (62° N.) in America the frozen ground does not extend beneath 26 feet.

Another effect of frost, not unworthy of notice, may be observed frequently in gravelly ground that is not much exposed to the sun. This consists in the skin of the soil being elevated often about an inch or a couple of inches on the top of a set of beautiful little pillars of ice. As stones, however, beyond the size of a walnut are seldom elevated by this process, the result is to cause these larger pieces and pebbles to sink deeper below the surface.

Even in summer the alternations of temperature undergone by soil exposed on the one hand to a full sun-heat through the day, and on the other to the rapid cooling by radiation during still clear nights, when it will be often at the freezing point, cannot be without some effect.

We now proceed to consider the conditions of *light* to which the soil is subject, and the effects resulting therefrom.

The light of the solar rays may be considerably enhanced by reflection from the clouds under favourable circumstances. This indirect or reflected light is most intense when thin fleecy clouds overspread the sky, and feeblest when it is covered by thick vapours, or when it is deeply azure. "The effect of the reflected light of the sky," says Forbes, "is always exceedingly intense; so much so as to give rise to the most paradoxical effects with regard to the intensity of solar radiation if neglected. Thus I have found the whole effect of the sun and sky in a bright April day in this country, when many white clouds were present, not very inferior to that of the most piercing sunshine of the most sultry day of the south of Europe unaccompanied by a single cloud. M. Kämtz found on the summit of the Faulhorn that the direct solar effect on Leslie's photometer was equalled and often exceeded by that of the diffuse atmospheric influence." (*Brit. Assoc. Report,* 1840, p. 62.) The amount of light, being lessened by the obliquity with which the sun's rays fall upon the surface of the ground, will consequently vary with the altitude of the sun, and with the hour and season. The rays of light like those of heat suffer diminution in passing through our atmosphere, and Leslie computed this loss at one-fourth upon a beam darted to the earth under the most favourable circumstances. Hence the thinner the strata of the atmosphere the stronger should be the

light, and consequently on the tops of high hills the celestial luminaries are seen to shine with a lustre unknown to the inhabitants of the plains; and I recollect receiving a description of the wonderful brightness presented by the morning star from one who had viewed it from the summit of one of the loftiest peaks in Spain. This diminution of the light is referred by Clausius to multitudes of fine vesicles of water, which even in serene weather float in the air and produce reflection.

Seeing that, with the exception of some observations and experiments by Petit and Scheele, little had been done towards the investigation of the chemical action of the solar radiations until the present century, we cannot but suppose that we are only yet beginning to be acquainted with their peculiar influence, and our present knowledge of the changes induced by them is confessedly very imperfect.

The attention however of some of the ablest philosophers and chemists of the day is at present keenly directed to the subject, and additions to our knowledge are continually dropping in. What has been done does not bear very decidedly upon the subject of the present paper, but is still worthy of attention. Ritter of Jena, in 1801, demonstrated the existence of rays beyond the spectrum which have no luminous power, but exhibit very active chemical agencies, and he inferred the existence of two sets of invisible rays, the least refrangible favouring oxygenation, whilst the most refrangible deoxidise, and later observers have confirmed his results. It was generally supposed that the chemical agency was confined more particularly to the blue and violet rays. To show the disproportion which exists in this respect between the energies of different rays, Berard "concentrated by means of a lens all that part of the spectrum which extends from the green to the extreme violet, and he concentrated by means of another lens all that portion which extends from the green to the extremity of the red. This last pencil formed a white point so brilliant that the eyes were scarcely able to endure it; yet the muriate of silver (a salt highly susceptible to the action of light) remained exposed more than two hours to this brilliant point of light without undergoing any sensible alteration. On the contrary, when exposed to the other pencil, which was much less bright and less hot, it was blackened in less than six minutes." (*Ann. de Chim.*, vol. lxxxv. p. 309.)

Chemical action has however been traced to every part of the prismatic spectrum, although the least luminous seem mos powerfully to affect inorganic bodies.

The heating agency may, in like manner, be separated from the luminous. Melloni, writing in 1835, says the rays can be passed through certain media "which absorb the whole of the calorific,

while they extinguish but a part of the luminous rays. The only substances hitherto employed by me are water and a peculiar species of green glass coloured by means of the oxide of copper. The pure light emerging from this system contains much yellow, and possesses at the same time a tinge of bluish green; *it exhibits no calorific action* capable of being rendered perceptible by the most delicate thermoscopes, even when it is so concentrated by lenses as to rival the direct rays of the sun in brilliancy." (*Scientific Memoirs*, i. 392.) This result has been lately called in question by Baden Powell, without, however, his adducing any experiments to the contrary. It will be seen, therefore, how the different actions of the solar radiations can be detached from each other. Thus to a considerable extent the calorific rays can be separated from the luminous, and the luminous from what has been termed the chemical.

Becquerel, however, seems to view the phenomena in a more philosophical manner. Extending Fresnel's hypothesis, that the chemical effects produced by the influence of light are owing to a mechanical action exerted by the molecules of ether on the atoms of bodies, so as to cause them to assume new states of equilibrium dependent on the nature and on the velocity of the vibrations to which they are subjected, he says it might be simpler to suppose: That a pencil of solar rays is the union of an infinite number of rays of different refrangibility, each ray arising from undulations of ether not having the same velocity. That by refracting a pencil of solar rays through a prism we have the solar spectrum, which possesses different properties on account of its different action on external bodies. That if we consider the retina as an organ which perceives the vibrations of the ether, it is only sensible to rays contained between certain limits of refrangibility, and the active rays form a spectrum, which in this case is found to be the luminous spectrum. And he goes on to say, "according to this hypothesis we shall bring back all the effects produced under the influence of light to the action of one same radiation upon different bodies, and there will be as many spectra as there are sensible substances." (*Scientific Memoirs*, iii. 556-7.)

Professor Moser of Königsberg has, however, attempted to show that no chemical decomposition is effected by light, and he thinks he can establish the following propositions:—"It is not necessary to suppose—and in those phenomena which have been best observed, it certainly is not the case—that light produces a separation of chemically combined bodies. The action of light is of such a kind that it may be imitated in a perfectly different manner, so that the idea of a chemical decomposition is fully refuted. Even the most continued action of light appears to

affect only the finest surface of bodies, and by no means to penetrate the usually so extremely thin layer of iodide of silver."

He shows that there is a condition of iodide of silver in which all the colours exert an influence upon it. The blackened state, which results from the action of light upon iodide of silver, is a composition not understood, but he considers it highly probable, if not fully proved, from a number of facts, that light produces no decomposition of iodide of silver. (*Scientific Memoirs*, iii. 423.) Some of Moser's conclusions have however been disputed.

That light, however, does exert a decided influence, which may be termed chemical, on many bodies, appears from a number of well-ascertained facts. Mr. Hunt, in the Report of the British Association for 1850, has collected a long list of those bodies which have been observed to be more or less susceptible of chemical change under the influence of the solar radiations, embracing various salts and compounds of silver, gold, platinum, mercury, iron, copper, manganese, lead, tin, and other less frequent metals; also combinations of phosphorus and ammonia, chlorine and hydrogen, nitric acid, and many resinous bodies, upon which he remarks as follows:—"From the extensive list which has been given it will be seen that the action of the solar radiations—so far from being confined, as it was formerly thought to be, to a few peculiar chemical compounds, which, existing in a state of exceedingly nice equilibrium, were liable to have their affinity disturbed by the operation of any external force—is so extensive that scarcely any body in nature, organic or inorganic, is independent of the solar influences, although their scales of sensibility to them are widely different." A somewhat contrary verdict this to Moser's.

Gay Lussac and Thenard observed that hydrogen and chlorine combine so rapidly in sunshine as sometimes to explode, although they do not unite at all in the dark, and only slowly in diffused light; and Dr. Draper, of New York, has stated the remarkable fact that chlorine which has been exposed to daylight or sunshine possesses qualities which are not found in chlorine made and kept in the dark.

The investigations of Dr. Daubeny and others have shown that the decomposition of carbonic acid by plants goes on with greatest rapidity under the influence of the most luminous rays, being most remarkable in the yellow; and Lindley states that the action of light upon cuttings of plants is little inferior to that of heat, while the important influence of the same agency on vital power is acknowledged on all hands.

With regard to the phenomena of *phosphorescence* induced by sunlight, Becquerel is of opinion that everything seems to prove

that its origin is electric, and that electrical manifestations appear to be quickened by the least luminous rays.

Dr. George Wilson ascertained that in darkness dry chlorine may be kept for three years in contact with colours without bleaching them, but that a few weeks sufficed to produce that effect in sunlight. The following are some of his results with other gases:—

Sulphuretted hydrogen, if made dry, and kept in darkness, does not bleach, but recovers its bleaching power with the assistance of sunlight, and acts also readily if moist.

Oxygen was found to be similarly affected, and also, in a fainter degree, *carbonic acid*.

Nitrogen exerts a faint bleaching action under exposure to sunlight, although it has no appreciable power in the dark, whether moist or dry. (*Brit. Assoc. Report*, 1851, p. 65.)

Some of these gases are present in the soil in large quantity, and the atmosphere is composed almost entirely of the last three; the above would show that under sunlight they act with an energy unknown in its absence; can the conclusion therefore be avoided that, although we are yet in a great measure ignorant of the precise influence it exerts, light doubtless affects in various ways the mutual action of the atmosphere and the soil, and that earth long buried, on being turned up to the surface, is exposed to a number of new forces tending to make its particles enter into fresh arrangements, and that among these light is not the least prominent in its effects?

Having considered the action derived from the sunbeams upon the soil, we have now to investigate the influence exerted upon it by the constituents of the atmosphere; before this can be done it must be shown what these constituents are. The great mass of the air is composed mainly of the two gases, oxygen and nitrogen, supposed to be not chemically combined but in a state of mechanical mixture. Its composition was discovered about the same time by Scheele and Lavoisier, and the researches of modern chemistry show that the relative proportions of these gases are as follows:—

100 measures of atmospheric air consist of—

Oxygen	20 or 21 volumes.
Nitrogen	80 or 79 „

M. Dumas, from recent careful analyses of air, has obtained the following results:—

	Air by Weight.	Air by Volume.
Oxygen	23·10	20·90
Nitrogen	76·90	79·10
	100·00	100·00

The atmosphere also seems always to contain a variable but small proportion of carbonic acid. The proportions of this ingredient in 10,000 volumes of air have been found to be, by

	Volumes.	
Dalton	6·8	
Saussure, maximum	5·74	From 104 observations taken near Geneva.
" mean	4·15	
" minimum	3·13	
Thenard	3·91	
Boussingault and Levy ..	3·253	At Paris in October.
" ..	2·989	At Arndilly, 16 miles from Paris.

Saussure's investigations were continued for two years, and he states that the proportion of carbonic acid varies at the same place within short intervals of time, is greater in summer than in winter, and more abundant in the night than in the day. Saussure also found that a continuance of heavy rains diminished the quantity of carbonic acid in the air by dissolving or carrying down part of it to the ground. When the soil is soaked with water it has the power of imbibing this gas, and its greater abundance in the air in frosty weather has been thought owing to the effect of the frost in keeping the air and soil dry. It has been found more plentiful in elevated situations and on mountain tops than in the lower grounds; wind having a tendency to augment it in those localities.

Another substance apparently always present, but in still smaller proportion, is ammonia. The quantity is so minute that its presence cannot be recognised in any given quantity of air, but Liebig showed that it could be detected by looking for it in rain-water, which carries down the ammonia in its passage through the air, and according to his own experiments *invariably contains it*, the form being that of a carbonate. The quantity is greatest in the first shower after a continuance of dry weather, and least after a succession of rains. Its amount probably varies in different places and at different times, and from the researches of Barral and Boussingault it would appear to occur more abundantly in the atmosphere surrounding cities.

Another atmospheric ingredient is nitric acid. Cavendish had observed that by passing electric sparks through moist air its volume was diminished, and an acid soluble in water was at the same time produced. He also established the fact that the oxygen and nitrogen of the air unite to form nitric acid when acted upon by electricity. Henry also noticed that ammonia mixed with oxygen is by the same agency converted into nitric acid.

Recent observations tend to prove that the quantity of nitrogen in the nitric acid of the air exceeds that contained in the form of ammonia—it would seem then that a direct oxidation of the

nitrogen must take place. Liebig however, though attributing considerable importance to the *ammonia* of the air as a source of nitrogen, considers that the nitric acid furnished to the earth in Europe by rains is so extremely small in amount that its influence cannot be considered as a source of nitrogen to plants. Chevallier noticed in the air at Paris ammonia and organic matters, and in London sulphurous acid. Boussingault and others add a small proportion of carburetted hydrogen.

The following constitution has been assigned to 10,000 volumes of dry air:—

Nitrogen	7,914
Oxygen	2,082
Carbonic acid	4
Carburetted hydrogen	a trace.
Ammonia	a trace.
	10,000

Sulphuretted hydrogen and phosphuretted hydrogen are also pretty generally present, but in infinitesimal proportions, apparently derived from the decomposition of animal and vegetable matter.

Dr. Witting, of Hoxter on the Weser, remarked that the atmosphere of a place contained in general the same foreign ingredients which the first fall of rain brings to the ground; such, for example, as traces of muriates, of free muriatic and carbonic acids, and of carburetted hydrogen gas. Rain which fell during a N.W. wind commonly contained much carbonic, together with traces of phosphoric, acid. The latter was discovered on several occasions in rain which had fallen during particular states of the weather; and Dr. Witting also states that certain plants exhale it, so that, when they are confined under glass, traces of this acid may be detected on the internal surface of the latter. (Quoted by Daubeny, *Brit. Assoc. Report*, 1836, p. 2.)

With reference to the above, it might be interesting to inquire to what extent the soil in the neighbourhood of large towns is enriched by the many ingredients that are found in the air over them. Thus, Dr. R. A. Smith, of Manchester, in his papers on the air and water of towns, speaking of rain, says, " Collected in a town, we know it to be a nauseous and black liquid; and when we go a mile from a town it is no less nauseous, although it loses its blackness. This would show that the black soot from chimneys is deposited very near a town, although the soluble substances are carried farther. Even many miles round a town the rain is unfit for use, without being passed through purifying materials. I have tried it as far as ten miles from Manchester; and it is probable that it is nowhere free from objection, as it

has been found necessary to take means to render it palatable even in agricultural districts."

Mr. Lawes has found at Rothamsted, 20 miles from London, that when the wind came from that metropolis it contained sooty particles. As soot is known to contain ammonia, it may therefore be to some extent a source of that ingredient in the atmosphere.

But it must not be supposed that we are thoroughly acquainted with all the constituents of the air, for the means at present possessed for determining them are insufficient to detect very minute quantities of matter. This is evident from the fact that the miasms of marshes owe their noxious qualities to some ingredient of a nature too subtle to be detected by the present chemical analysis; and Seguin, in examining the infectious atmosphere of an hospital whose odour was almost intolerable, could discover no appreciable peculiarity in its composition. A variable amount of watery vapour is always diffused through the atmosphere: its absolute quantity is usually greatest in summer on account of the temperature being higher; but the dryness of the air depends less upon the absolute quantity of vapour that may be present than on its condition as to saturation. The warmer the air is, the more water will it contain; hence the atmosphere is moister during summer than in winter, although the absolute quantity of sensible vapour in it may be much less; but few data exist as to the amount of this ingredient in the air. According to Dr. Anderson, of Glasgow, 1000 volumes of air contain on an average about 8 volumes of watery vapour. Amongst the constituents of the atmosphere may also be enumerated the substance termed ozone, which has of late years been brought under notice by Dr. Schönbein, of Basle, and which would appear to be very frequently present. Traces of iodine have also been found by Chatin to exist in the atmosphere.

The properties of these different ingredients of the atmosphere, and their actions, chiefly in so far as they are related to the subject of this paper, may now be touched upon.

Oxygen, Ozone.—These two substances are taken together, as their action is probably similar, differing mainly in degree. The chief chemical properties of the air are perhaps due to the presence of this element (which is a transparent colourless gas somewhat heavier than common air), the greater part of the changes which the mineral and organic matter of the soil undergo proceeding from its numerous and powerful affinities. For most simple bodies it has a very strong attraction, combining with all the elementary bodies save perhaps fluorine. The act of combining with it is called oxidation; this may take place very rapidly with the evolution of heat and light, giving rise to the pheno-

mena of combustion, or it may occur slowly without sensible light and heat, as in the rusting of iron and the gradual oxidation and decay of organic matters, whether animal or vegetable, which are thus resolved into forms of combination suitable for the food of plants.

As gradual oxidation is but a sort of slow combustion, there is probably also a small but continual evolution of heat during the process, the totality of which is equal to that resulting from rapid combustion, just as it is found that the same amount of heat is required to cause water to pass into the state of vapour, whether this takes place by rapid ebullition or by insensible evaporation. The oxidation, therefore, of the matters of the soil, especially where it contains much organic substances, may not be without some beneficial effect on the temperature of the ground.

Oxygen is the most abundant and important of the elementary bodies, 8-9ths of the water of the globe being composed of it, and about 1-5th of the air, besides a large amount of all the rocks, earths, and animal and vegetable substances. It is indispensable to the existence of all animated nature, and to the decay of dead organic matter. 100 cubic inches of water, from which the air has been expelled by boiling, dissolve, according to Henry, 3·55 cubic inches of oxygen. According to Anderson it is found in plants in quantities ranging from 30 to 36 per cent.

So strong is the affinity of oxygen for organic matter in a state of putrefaction, that the latter is one of the most powerful deoxidizing agents known; so much so as to be capable of reducing even sulphate of lime in the state of gypsum, and of converting sulphate of iron into sulphuret of that metal; and in the neighbourhood of iron exposed in these conditions organic matters are frequently found coated or penetrated with crystals of common pyrites, or bisulphuret of iron, the oxygen going to form carbonic acid and sulphuric acid, while from solutions of gypsum carbonate of lime is a resulting product. It will afterwards be shown that water and dew are powerful oxidising agents, from the large amount of oxygen they hold within them.

Ozone is the name given by Dr. Schönbein, of Basle, on account of its pungent smell, to a substance produced by passing electricity through dry oxygen, or when water is decomposed by the galvanic current. Its odour is similar to what is sometimes perceived in thunderstorms; and as electricity may be shown to be more or less generally present in the air, it is supposed that ozone is very frequently developed. Faraday found at Brighton that the pure air from the ocean abounds with it; and Schönbein met with it plentifully during a storm on the Jura. Its composition is not as yet clearly understood, and it has been thought

that there may be more than one compound included under the name. It contains at any rate oxygen in large quantity, if indeed it is not, as Faraday has hinted, merely that element rendered more energetic in its action. Schönbein himself regards it as a combination of oxygen and hydrogen. Its action appears to be that of rapid oxidation, changing protosalts into persalts, sulphurets into sulphates, nitrous acid into nitric acid, and so on: it acts most powerfully upon metallic bodies, and destroys organic substances even when diluted with much air or oxygen, and bleaches vegetable colours like chlorine. Uniting readily with fœtid gases, it has a most beneficial effect in purifying the air, and it is accordingly supposed that this property of thunderstorms can be accounted for by its production during their continuance. In some large towns, such as London and Manchester, it has not been met with; but as its presence in the atmosphere would appear to be pretty general, its action on the soil should not be overlooked.

Nitrogen.—The uses of the nitrogen of the atmosphere are not well understood; it has been thought to act chiefly as a diluent of the oxygen. It is a transparent colourless gas, rather lighter than common air, and is distinguished more by its negative properties than by any striking quality of its own: its compounds are generally easily decomposed. It is, however, an important and necessary ingredient in organic bodies, and is found in plants to the extent of from 1 to 4 per cent., and, in union with hydrogen, it forms the important compound ammonia, and it is chiefly through this medium that it has been thought to enter into the structure of plants. It occurs but very sparingly in the minerals of the soil, and hence the necessity of supplying it in manure: 100 cubic inches of boiled water absorb, according to Dalton and Henry, 1·56 cubic inches of nitrogen.

Carbonic Acid is not, like the two former, an elementary or simple substance, but is a combination of carbon and oxygen. Forming but a small proportion of the atmosphere compared with the nitrogen and oxygen, its relations to plants are yet most important, and the action of the air upon the soil is largely dependent upon it. Nearly 50 per cent. of the dry substance of plants consists of carbon; and as this is supposed to be derived from the carbonic acid which they absorb, we may look upon the latter as the most important food of vegetables. The carbon of animals is also derived from the same source. This gas is absorbed by water to an extent proportionable to the pressure, the water taking up about its own volume; if the pressure, therefore, is great, a very large quantity of the gas will be held in solution, as is seen in champagne and other effervescing liquors. The addition of a little carbonate of soda will make the water absorb a still greater amount

of carbonic acid, and the combination of this with high pressure, as in the case of soda-water, will cause a very highly charged solution of the gas. Carbonic acid is a transparent gaseous substance, considerably heavier than common air, and, as its name implies, is possessed of acid properties, entering into combination with bases to form salts, which are termed carbonates; as it is, however, but a feeble acid, its salts are generally decomposed in the presence of other free acids, with effervescence: the acid also may be driven off by heat, which, however, sometimes requires to be very intense. The carbonates are more or less soluble in water, many of them, however, but very sparingly so; but when the water contains an excess of carbonic acid, its solvent power is thereby much increased. Carbonic acid is capable of being liquefied under great pressure, and may even be reduced to the solid form. It dilates remarkably by heat, its expansion being more than four times that of air. It is formed abundantly by the decay of dead organic matter, the carbonaceous substances of the soil uniting with oxygen and thereby giving rise to it in considerable quantity. It is found also, to a greater or less extent, in all springs, and indeed in all natural waters. Through its solvent powers it is that the mineral matters of the soil are brought into forms fit for being taken up by the rootlets of plants. Speaking of the mineral ingredients of the soil, Daubeny says, "All that which water impregnated with carbonic acid fails in dissolving ought to be regarded as *at present* contributing nothing to the food of a plant, although it may ultimately become available for its purposes." (*Eng. Agricult. Journ.* VII. 237.)

Dr. Struve, of Dresden, stated that he extracted alkali from granite by merely filling a tall vessel with fragments of the stone, pouring upon it distilled water, and suffering a stream of carbonic acid gas to bubble slowly through the materials.

Some interesting experiments were made by Professors W. B. Rogers and R. E. Rogers, of Virginia. Referring to the prolonged digestion of minerals in water, and carbonic acid water, at the ordinary temperature of 60°, they gave results obtained with hornblende, epidote, chlorite, mesotype, &c. (minerals which often largely enter into the composition of the soil), showing that the amount of solid matter dissolved by the carbonated water in many cases is quite sufficient for a qualitative analysis, even when the digestion has only been continued for 48 hours; when further prolonged they have procured from the liquid a quantity of lime, magnesia, oxide of iron, alumina, silica, and alkali, the dissolved ingredients of these minerals amounting sometimes to nearly 1 per cent. of the whole mass. Their experiments further demonstrate that in water impregnated with carbonic acid, carbonate of mag-

nesia is much more soluble than carbonate of lime. Another fact of some interest, also noticed in their experiments, was the comparative readiness with which the magnesian and calcareo-magnesian silicates yield to the decomposing and dissolving action of carbonated water and even simple water, thus explaining the rapid decomposition of most rocks composed of hornblende, epidote, &c., without calling in the agency of an alkali; enabling us also to trace the process by which plants are furnished with the lime and magnesia they require from soils containing these silicates, without having recourse to any mysterious decomposing power of the roots of the growing vegetables. (*Brit. Assoc. Report*, 1849, p. 40.)

Bischof has also remarked, that, although long-continued boiling in water will separate the alkali from a mass of volcanic *tuff*, the process is facilitated by the presence of carbonic acid, so that he conceives the disintegration of felspathic rocks to be brought about by water impregnated with that ingredient.

Professor Bunsen, of Marbourg, experimenting upon the Palagonite *tuff* of Iceland, of which the following is the composition—

Silica	37·947
Sesquioxide of iron	14·751
Alumina	11·619
Lime	8·442
Magnesia	5·813
Potash	0·659
Soda	0·628
Water	16·621
Residue	4·108

—found that under the action of water, at 212° F., silicic acid, potash, and soda were dissolved; but when the water was saturated with carbonic acid and allowed to act upon the pulverized rock, *all the constituents, with the exception of alumina and oxide of iron*, were dissolved in the form of bicarbonates.*

1000 grammes of the water solution, after 12 hours' digestion, contained—

	Grammes.
Silica	0·03716
Soda	0·00824
Potash	0·00162
	0·04702

* Silicates of potash and soda, silicate of lime, protosilicate of iron, and probably protosilicate of manganese, are decomposed by carbonic acid at ordinary temperatures; but silicate of alumina and persilicate of iron are not acted upon by carbonic acid, as it does not combine with alumina, nor with peroxide of iron. The alkaline carbonates also bring about many decompositions in the mineral matter of the soil.

1000 grammes of the carbonic acid solution, after 4 hours' digestion, contained—

	Grammes.
Silica	0·09544
Bicarbonate of lime	0·16893
" magnesia ..	0·05333
" soda	0·06299
" potash	0·00189
	0·38258

The powerful action of water containing carbonic acid, upon carbonate of lime, is well known, removing the lime in the form of bicarbonate; should the water holding the lime in this state of solution be exposed to evaporation, the lime is deposited, and in this way great masses of limestone are formed—witness the *travertino* of Italy and the large accumulations in the plains of Pamphylia. The same is also seen in the stalactitic caves in this and other countries.

The late Sir H. De la Beche, speaking of the decomposition of silicates, and remarking that certain of them—for example, those of potash and soda—are not difficult to be dissolved when free carbonic acid is present, goes on to say: "Mr. Henry informs me that, when experimenting upon silica, he found that a silicate of soda was decomposed even by the carbonic acid of the atmosphere, and the silica deposited, its state and appearance being much affected by the degree of concentration of the solution." (*Geological Observer*, p. 606.)

As with silicates of potash and soda, so it is with the silicate of lime in the presence of water containing carbonic acid, decomposition taking place with the formation of carbonate of lime, or, if the carbonic acid be in abundance, bicarbonate of lime ready to be removed in solution. (*De la Beche.*)

Way has moreover shown the solvent action of carbonic acid upon the double silicate of alumina and ammonia. Thus, while one gallon of distilled water dissolved from this salt but one grain of ammonia, the same quantity of water saturated with carbonic acid dissolved upwards of 2½ grains. (*Eng. Agricult. Journ.*, XXIX. p. 136.)

Again carbonic acid is, says Liebig, the indispensable condition for the entrance of the phosphates into the vegetable organism; for phosphate of lime, although insoluble in pure water, yet is, like carbonate of lime, soluble in water containing free carbonic acid; and, according to Werner, it is the carbonic acid that decomposes the felspar of rocks, an opinion which appears to be pretty generally entertained.

Dr. Anderson, of Glasgow, says, "The oxygen of the atmosphere acts upon the organic matters of the soil and produces a

constant although slow evolution of carbonic acid, which is absorbed by the moisture contained in the soil, and exerts a solvent action on its constituents. In fact, although a very feeble acid, carbonic acid, by its continuous action, is constantly effecting the solution of new quantities of the constituents of the soil." (*Enc. Brit.*, 8 ed. ii. 395.)

On the backs of veins containing sulphuret of lead, exposed to the air, the carbonates of that metal are often found. A pot of Roman copper coins was got, a few years since, in Cardiganshire, not far from the surface, and the coins themselves had been exposed to the action of atmospheric influences; the waters, containing common air and carbonic acid, finding their way to them, had produced the red oxide of copper on the surface of some of the coins, beautifully crystallised, while in others the further change into the carbonate had been so effected as to present the usual mamillated character of malachite. Illustrative specimens of these coins are now in the Museum of Practical Geology. Many ancient bronzes shew similar changes. In the refuse of the old Derbyshire mines the small fragments of sulphuret of lead are found wholly changed into the carbonate, and a similar action is observed upon the sulphuret of zinc. (*De la Beche.*)

Aqua regia is known as about the most powerful solvent we have, dissolving even gold and platinum; but the long-continued action of water containing carbonic acid will dissolve what even aqua regia fails to do in a short time, as the following experiment by Polstorff and Wiegmann clearly shows. These chemists boiled some white sand with a mixture of nitric and muriatic acids, and, after completely removing the acid by washing the sand with water, they exposed it, thus purified, to the action of water saturated with carbonic acid gas. After the lapse of 30 days this water was subjected to analysis, and was found to contain in solution silica, carbonate of potash, and also lime and magnesia; thus proving that the silicates contained in the sand were unable to withstand the continued action of water containing carbonic acid, although the same silicates had resisted the short action of the aqua regia. And it is also known that felspar is unable to withstand the solvent action of water saturated with carbonic acid, although it is scarcely affected by being left in contact with cold muriatic acid for 24 hours. (*Liebig*, *Chem. of Agriculture*, 3rd ed. p. 92.)

The air contained in the pores of the soil is often proportionally much richer in this gas than the atmosphere, especially when it contains much decaying organic matter, the earthy substance having the property of condensing the carbonic acid within its interstices. Boussingault, investigating this subject in 1852, found that in soil recently manured the air fre-

quently contained 400 times as much carbonic acid as the general atmosphere.

These observations will perhaps suffice to show the extensive agency of this ingredient of the atmosphere upon the varied matters of the soil; its importance to the vegetable kingdom can hardly be exaggerated, for it is the vital breath of plants, without which they would soon perish; its action upon the soil is that of an acid, decomposing the substances with which it comes in contact, and combining with the bases to form carbonates or bicarbonates, which being generally soluble in water are thereby enabled to enter into the roots of plants. Compared with some of the well-marked acids—such as the sulphuric, nitric, or hydrochloric—its powers are indeed feeble; but a rapid action upon the soil is not wanted, would indeed be injurious and exhaustive, for the riches of the soil would thereby be soon wasted. A gradual, steady, solvent power, adapted to the continued necessities of plants, and most active in the summer season, is the thing here required, and in this agent we find that Nature has admirably supplied it.*

Carburetted Hydrogen is a colourless gas, about half the weight of common air, scarcely soluble in water, and is a compound of carbon and hydrogen. It would appear to be a neutral body, not forming compounds with acids or bases. Stagnant water, containing vegetable matter, frequently gives off this gas, on account of which it has received the name of *marsh-gas*, and also *fire-damp*, from its explosive property, so fatally known in coal-mines. As I am not aware in what manner it can affect the materials of the soil, it need not be longer here considered.

Ammonia, Nitric Acid.—Although, relatively, the amount of these ingredients of the atmosphere is but minute, yet, looking upon the air as a whole, their quantity is considerable. Taking the ammonia at even the low estimate of Fresenius (in 1,000,000 parts of air 0·098 by day, and 0·169 by night), it has been computed that our atmosphere contains altogether 50,000,000 tons of it, and the amount of nitric acid would appear to be considerably greater. It is only of late years that researches have been made into the proportions of these substances in the air, and the results of different investigators disagree, which might have been expected, as, like the carbonic acid, their amount varies probably according to time and place. Although a paper by Professor Way has recently given to the readers of the English Agricultural Journal a summary of the existing know-

* May not one of the principal uses of the *mould* or carbonaceous matter of cultivated ground be its power of dissolving the mineral matter of the soil by virtue of the carbonic acid, organic acids, ammonia, and nitric acid, generated in the course of its decay.

ledge on the subject, yet, as some important investigations in this country have since then been published by Mr. Lawes, it may not be out of place here to give some of the results that have been arrived at.

Ammonia found in 1,000,000 parts of air, by—

Kemp		3·680
Graeger		0·323
Fresenius (by night)		0·169
„ (by day)		0·098
Ville, from 16 experiments	interior of Paris	0·024
	environs of Paris	0·021

Ammonia found in 1,000,000 parts of rain-water, by—

Barral, mean of 5 months' observations at Paris (confirmed by Boussingault)	3·490
Boussingault, mean of 6 months' observations in open country in Alsace	0·744
Lawes and Gilbert, mean of 14 months' observations in open country at Rothamsted	0·980

Nitric acid found in 1,000,000 parts of rain-water by—

Barral, mean of 5 months' observations at Paris	16·250

Mr. Lawes has also investigated the proportions of nitric acid in rain-water, and, although he did not consider his experiments satisfactory enough to be published, yet he has stated that their tendency is to confirm the fact of the larger proportion of nitrogen occurring under this form than in that of ammonia.

Boussingault has also found the water of dew and fogs to be much richer in ammonia than rain-water.

As the air generally sweeps over the ground at a considerable velocity, each particle of the surface is continually brought into contact with a fresh supply, and the well-known powers of the earth to absorb the ammonia so presented to it shew that a considerable quantity must thus enter into its pores.

Ammonia has a powerful affinity for water; according to Thos. Thompson, water, at the common temperature and pressure, takes up 780 times its bulk of this gas, and under strong pressure it is absorbed in still greater quantity. Under a pressure of 6½ atmospheres ammonia becomes a fluid; it is also liquefied at a temperature of $-40°$. Ammonia has the properties of an alkali or base, uniting with acids to form salts, which are generally soluble in water; some of them are, like itself, volatile at the ordinary temperature, while others require a strong heat to decompose them. The ammonia of the air probably exists in the form of a carbonate, and Mr. Way found that, if air charged with carbonate of ammonia, so as to be highly pungent, is passed through a tube filled with small fragments of dry clay, every particle of this gas is arrested; and, in the same manner, if into a bottle filled with air similarly impregnated a little ordinary

dry soil is thrown, and the bottle then shaken, all ammoniacal smell will disappear. Way attributes this property, in a great measure, to the double silicate of alumina and lime, which he found had so great an avidity for carbonate of ammonia that a few grains of the lime-silicate placed under a bell-jar, along with some pieces of dry carbonate of ammonia, in a few hours absorbed between 2 and 3 per cent. of the volatile alkali; the carbonic acid of the carbonate of ammonia combining with the lime to form carbonate of lime, while the ammonia forms, with the alumina, a double silicate of alumina and ammonia. (*Eng. Agricult. Journ.*, XXIX. p. 138.)

De Saussure observed that sulphate of alumina exposed to the air passed into ammoniacal alum. Vauquelin also detected ammonia in the oxide of iron produced by the exposure of that metal to the action of air and water; and Chevallier and Boussingault found it in the native oxides of iron; Austin also states that it is always present when iron is oxidated by air and water. Iron, however, according to Guibourt, has the power of decomposing water when it rusts, abstracting the oxygen and liberating the hydrogen, and it is possible that ammonia may be formed in the process; be this as it may, however, peroxide of iron, like other porous bodies, greedily absorbs ammonia and many other gaseous substances.

The organic matters of the soil have also a strong affinity for this gas; peat absorbs a large quantity, and so great is the attraction of the humic and other organic acids of the soil for ammonia that they can hardly be freed from it. (*Anderson.*)

In addition to the ammonia which the atmosphere supplies directly, it furnishes it also indirectly by its action upon the nitrogenised matters that may be in the soil; this organic matter may be decomposed by the conversion of its nitrogen either into ammonia or into nitric acid. Dr. R. A. Smith, of Manchester, has shown that, if the soil is very alkaline and moist, the conversion of the organic matter into ammoniacal compounds is very rapid. He put some soil not very rich in organic matter into this condition by the assistance of a little ammonia, and the consequence was the rapid occurrence of a very intense putrefactive decomposition. In a paper to the Philosophical Society of Manchester he showed that, through the rapid decomposition of organic matter by moisture and heat, ammonia is formed so abundantly that in hot weather, on peat-land, it may be found perceptible directly by the senses.

An important action of the ammonia is its power of dissolving the mineral matter of the soil. Kuhlman, in reference to this, writes, "In order fully to appreciate the effect of ammoniacal salts, it is necessary to point out that they promote the entrance

of mineral salts into the plant. Phosphate of lime, phosphate of magnesia, and silica, can by the aid of carbonate of ammonia become somewhat soluble and absorbable. Every soil contains carbonate of lime, which is rarely free from alkalies, and this under the influence of solar heat will decompose sal-ammoniac and sulphate of ammonia, by which means soluble salts of lime and carbonate of ammonia are produced." (*Comptes Rendus*, XVII. 1118.)

Some of the mineral constituents of plants are dissolved in the soil only by water containing carbonic acid or some salt of ammonia. That the nitric acid and ammonia of the atmosphere probably exercise some solvent power upon the mineral matter of the soil, the experience of Mr. Lawes and others shows, for the produce of nitrogenised matters in the crop are not porportional to the supply of nitrogen given to the soil in the shape of ammoniacal manures, there being a disappearance of ammonia in some manner which perhaps can be accounted for most feasibly on the supposition that it acts as a solvent upon the mineral matter of the soil, and thus is the means of introducing into the plant those necessary substances which might without it remain in an insoluble form. It would, indeed, seem that this dissolving power of ammonia upon the silicates, phosphates, and other earthy matters of the soil, is perhaps a more important property than its use merely as a supplier of nitrogen, for the amount of it withdrawn from the soil is sometimes four times as much as appears in the crop.

Nitric acid and ammonia have been spoken of together, as their action is probably similar, both as regards the soil and the crop growing upon it, and they may likely replace each other in those respects.

When it is considered that many of the nitrogenised constituents of the crops seldom find their way into the dung-heap, but are sent off the farm in the grain and live stock sold, and that nitrates and ammoniacal manures are expensive articles to purchase, then the amount of these ingredients of the atmosphere, as available sources of nitrogen to the soil and the plants that grow upon it, becomes a very interesting inquiry; for if it can be shown that, by certain not too expensive modes of management, the surfaces of our fields can be made to catch enough of these substances for the wants of each crop, a great advantage would be gained, and a standing difficulty be removed. Liebig, in a recent publication, writes, "I consider myself as perfectly justified in concluding from my experiments, that on ordinary farms, provided we give to the soil the proper *physical quality* and *composition*, there may be, by degrees, such an amount of ammonia collected, or condensed from the atmosphere, as to be

more than sufficient, with the available mineral constituents present in the soil, to obtain the maximum of produce for each soil. This of course does not exclude the feasibility of attaining a still higher produce, if we increase the proportion of mineral and atmospheric constituents in the soil." (*Principles of Agricultural Chemistry*, p. 45.)

Ammonia is produced in many cases where nitrogen at the moment of its liberation from compounds containing it is met by hydrogen.

Water.—The action of the watery vapour and rains of the atmosphere still remains for consideration. Without the presence of water little chemical action would take place, and the oxidation of minerals would probably not be effected. Perfectly dry air has little combining power, and has no effect whatever upon iron; the extreme slowness with which even the moderately dry air of the higher regions of the atmosphere influences bodies exposed to it is evidenced by an experiment of M. Zumbstein, who fixed a polished iron cross on the summit of Monte Rosa, in the Alps, in August, 1820; on visiting it again in August, 1821, he found it neither rusted nor corroded, but with merely a tarnish the colour of bronze. The temperature of the air was 21° F.; barometer 16 inches 42 lines; and height above the sea 14,086 feet. Neither does pure water deprived of all air, according to Marshall Hall, act upon iron at any temperature below 212° F., and at that but slowly.

Air and water, therefore, at ordinary temperatures, taken separately, are quite neutral in respect to iron, and to many other bodies, but taken together the case is widely different; the conditions most favourable for the rapid oxidation of iron consisting in its exposure to alternations of wet and dry, or to air covered with an indefinitely thin film of water constantly renewed. (*Mallet, Brit. Association Report for* 1840, p. 256.)

Water, owing partly to its own extensive affinities, and also to its elements, the oxygen and hydrogen of which it is composed, is itself a chemical agent of great power, and in consequence of its great solvent action it is never quite pure in nature: even rain-water before reaching the ground contains, as we have seen, atmospheric air, ammonia, nitric acid, and carbonic acid; it also frequently contains sea-salt, found more abundantly during or immediately after a gale off the ocean. The air found in water from newly-fallen snow melted is much richer in oxygen than atmospheric air; according to Gay Lussac and Humboldt it contains 34·8 per cent of oxygen, and the air in rain-water contains 32 per cent. of that gas. Air or oxygen dissolved in water is in a condensed state, and hence in a condition highly apt for combination. Rain-water, when newly fallen, frequently con-

tains one-fifth of its volume of oxygen. According to Guibourt, when a piece of iron is immersed in such water the whole becomes electrically excited. The water, rendered more negative by contact with the iron, repels its dissolved oxygen, while the iron, become more positive by the contact of water, exercises an unusual affinity for the oxygen. Supposing the surface of the metal everywhere uniform, a film of oxide is soon produced over it, and, this once effected, decomposition proceeds with increased rapidity; for as every metal is positive with regard to its own oxides, it follows that the film of rust and the iron beneath now form a voltaic couple of greater energy than the last; and whereas the electric energies were before only sufficient to bring the dissolved oxygen of the water into combination with the iron, they now become sufficient to decompose the water itself, and hydrogen commences to be evolved. (Quoted by Mallet from the *Journ. de Pharm.*, 1818.)

According to Thomas Thompson, the air in the water of the river Clyde amounts to 3·113 per cent., and consists of 70·9 of nitrogen and 29·1 of oxygen.

Newly-boiled water has the property of absorbing a portion of all gases brought into contact with it, the absorption being promoted by shaking. The following table shows the quantities of different gases taken up by water that has been deprived of all its air by ebullition:—

100 cubic inches of water at 60° and 30' Bar. absorb of

	Dalton and Henry.	Saussure.
	Cubic Inches.	Cubic Inches.
Carbonic acid	100·	106·
Oxygen	3·7	6·5
Nitrogen	1·56	4·1
Hydrogen	1·56	4·6
Sulphuretted hydrogen	100·	253·
Olefiant gas	12·5	15·3
Carbonic oxide	1·56	6·2
	T. Thompson.	
Ammonia	78000·	

The estimate of Saussure is thought to be generally too high. The following table shows the solubility of certain substances in water:—

	100 of Water at 60° dissolve
Alumina	0·000
Ammonia, nitrate	200·000
„ sulphate	50·000
Potash, sulphate	9·600
„ nitrate	27·000
„ carbonate	121·000
„ bicarbonate	25·000

Sodium

	100 of Water at 60° dissolve
Sodium, chloride	37·000
Soda, nitrate	43·600
„ sulphate	83·600
„ carbonate	20·500
„ bicarbonate	8·700
„ phosphate	24·700
Lime, sulphate	0·217
Magnesia	0·019
„ sulphate	114·000
Iron, protosulphate	70·000
Lime, carbonate	0·009
„ hydrate	0·128

Water combines with anhydrous bases, forming hydrates of these bases, of which slaked lime is a familiar example, being a hydrate of lime; it also forms hydrates of neutral salts. Again, it combines with both hydrated and anhydrous salts in the form of what is called water of crystallization, as is instanced in the family of minerals named zeolites. It also unites with dry acids to form hydrated acids; indeed some of these bodies without that water seem to want their acid property, e. g. dry sulphuric acid.

Rain-water, being derived by the action of evaporation and wind from the sea, probably often contains traces of all the matters found to compose the water of the ocean; it may therefore be the means of conveying a very sensible amount of many salts to the soil. The following analysis by Schweitzer will show the composition of the waters of the English Channel, and is contrasted with another of the waters of the Dead Sea by a pupil of Dr. R. D. Thomson:—

	English Channel.	Dead Sea.
Chloride of sodium	27·059	76·50
„ potassium ..	0·765	23·30
„ magnesium ..	3·666	95·60
„ calcium	.. .. ..	22·45
„ aluminum ..	.. .. ..	0·24
Bromide of magnesium ..	0·029	2·31
Sulphate of lime	1·406	0·86
„ magnesia ..	2·295	
Carbonate of lime	0·033	traces.
Ammonia	trace	
Fixed salts	35·253	221·26
Water	964·747	778·74
	1000·000	1000·00

I have little doubt therefore that minute quantities of many of these important salts are conveyed to the soil through the medium of rain; take for instance the first of the list, the chloride of sodium: at Penicuik, according to Dr. Madden, the rain that falls is said to contain so much common salt as alone to convey

640 lbs. to every acre in the year. (*Johnston's Elements of Agricult. Chemistry*, 5th ed., p. 216.) Can it be thought that this ingredient is alone snatched up from the sea-waters and all the rest left behind? To suppose so would be absurd, and although the others may exist in the rain in proportions so small as to have escaped notice, like the ammonia and nitric acid, yet there can be little doubt that the total amount thus carried down to the soil in a season must have an appreciable influence on vegetation. The annual average fall of rain in Britain on the plains amounts to about 554,000 gallons per imperial acre, and on the mountain ranges to nearly double this: although therefore the amount of any of these salts in a gallon may be quite inappreciable, yet when multiplied 554,000 times the product may give a very important quantity.

Rain-water on reaching the ground begins to dissolve a part of almost everything it meets with in its passage through the soil, such as carbonates and phosphates of lime, magnesia, and iron, silicates of lime, potash, and soda, organic matters, &c. By looking into the mineral matters found in springs and rivers, which are merely rain-water that has percolated through or over the soil, some idea will be got of its solvent powers. The following table shows the various substances found in some well-known rivers:—

	In an Imperial Gallon. Grains.			In 22 lbs. Grammes.
	Thames at Twickenham.	Clyde at Waterworks.	Seine at Notre Dame.	Nile.
Carbonate of lime	12·76	5·13	6·17	5·30
" magnesia	1·03		2·29	7·43
Peroxide of iron	.. ..	.. ..	.. ..	0·53
Sulphate of lime	0·45	0·25	1·39	
" magnesia	.. ..	.. ..	.. ..	0·53
" soda	2·00	.. ..	0·69	
" potash	0·66	trace		
Chloride of calcium	1·75	0·18		
" magnesium	.. ..	0·10	0·69	
" sodium	.. ..	1·84	.. ..	4·77
Nitrates	.. ..	indications	traces	
Silica	0·27	0·54	0·55	1·06
Alumina				1·59
Organic matter	3·48	1·49	traces	0·53
Carbonic acid	.. ..	.. ..	.. ..	12·19
	22·40	9·53	11·78	33·93

The following table contains the analyses of two springs in the Malvern hills of South Wales, from the *Memoirs of the Geological Survey*, vol. ii. p. 17. 'The rocks of these hills are composed, according to Mr. Phillips, principally of the minerals, quartz,

felspar, mica, chlorite, hornblende, and epidote; of these felspar is the most abundant, hornblende next, and then quartz and mica. Epidote in small quantities at any one place. Of rarer occurrence are, magnetic iron-ore, sulphuret of iron, sulphate of barytes, carbonate of lime and carbonate of iron. They are in short a range of igneous or trap rocks. The surface of the hills is uniformly and excessively dry, says Mr. Phillips; the rain-water sinking into innumerable fissures and reappearing at lower levels in springs. The following table will therefore show what water will dissolve in passing through such substances:—

	Holy Well. Temperature 49°—50°.	St. Ann's Well. Temperature 47°—49°.
Carbonate of soda	5·330	3·550
„ lime	1·600	0·352
„ magnesia	0·920	0·260
„ iron	0·625	0·328
Sulphate of soda	2·896	1·480
Muriate of soda	1·558	0·955
Residuum	1·687	0·470
Grains of solid ingredients in 1 gallon	14·611	7·395

The effect of the carbonic acid in the rain-water will be observed, the greater part of the salts being washed out in the form of carbonates. These springs are at the common temperature; the following will show the effect of an increased temperature: the first analysis is of the waters of the Great Geyser in Iceland, by Dr. Sandberger, which passes also through igneous rocks; the second is by Berzelius, of the mineral waters of Carlsbad:—

	Geyser. Grains in 1,000.	Carlsbad. Temperature 165° F. Grains in 1,000.
Carbonate of soda	0·1939	1·25200
„ ammonia	0·0083	
„ lime		0·31219
„ strontia		0·00097
„ magnesia		0·18221
„ iron		0·00424
„ manganese		trace.
Sulphate of soda	0·1070	2·58714
„ potash	0·0475	
„ magnesia	0·0042	
Sulphide of sodium	0·0088	
Chloride of sodium	0·2521	1·04893
Fluoride of calcium		0·00331
Phosphate of lime		0·00019
„ alumina		0·00034
Silica	0·5097	0·07504
Carbonic acid	0·0557	5 cubic inches in a wine pint.
	1·1872	5·46656

The following are the substances contained in an imperial gallon of the waters of the Artesian well in Trafalgar Square, London, according to the analysis of Dr. Lyon Playfair:—

	Grains.
Chloride of sodium	25·724
Subcarbonate of soda	0·709
Bicarbonate of soda	14·564
Sulphate of soda and potash	18·432
,, magnesia	1·157
Silicate of alumina, with a trace of oxide of iron ..	0·835
Carbonate of lime	3·085
,, magnesia	2·363
Phosphate of magnesia	0·043
Loss	0·276
	67·188

As estuary waters may percolate into the chalk below London, the large amount of chloride of sodium may be due in great measure to that source.

These analyses will serve to show the effect of water in dissolving the mineral matters of the soil. The action of ammonia in this respect has been already alluded to, but water containing common salt (*chloride of sodium*) has also a great solvent power upon some substances, surpassing even that of carbonic acid water. Mr. Way for instance found that the double silicate of alumina and ammonia was affected in the following manner:—

	Grains.
1 imperial gallon of distilled water dissolved about	1·000
,, of water saturated with carbonic acid	2·527
,, of water containing 0·1 per cent. of common salt	3·320
,, of water containing 1·97 per cent. of common salt	23·100

The last, it will be observed, is more than twenty times as much as what was dissolved by pure water, and more than nine times as much as was taken up by water saturated with carbonic acid. It has been shown how largely salt occurs in rain-water in some places; its solvent effect may therefore be often of some benefit. Mr. Way suggests that this effect of salt may be the means of supplying silica to the stems of plants, and thus explain the influence which has been observed of its application strengthening the stems of the grain crops. An instance of this came under my own observation. On the 11th June, 1853, having observed part of a field of oats so very luxuriant that I thought the crop would lodge and be rotted, I sowed upon the rankest bit of it (being about 1·162 acre imp.) 2 cwt. of salt during a very heavy rain. Some of the adjacent portions were also offering to be too luxuriant, although not so much so as the piece thus treated. But when harvest arrived, the salted bit,

although it did eventually go down, did not do so until it had filled and ripened, being about the first ready of the whole field—the cutting was indeed begun at it; whereas the portions adjoining, that got no salt, lodged much worse, never thoroughly ripened, and were many days later. The nature of the soil was a light loam, naturally wet, but thoroughly drained. I ought, however, to mention that this effect does not always happen; for the very same season, I caused one whole ridge in the middle of another field to be sown with common salt at an earlier part of the summer, at the rate of 3 cwt. per imperial acre, and saw it done myself, as in the other case. But in this instance I could see no influence the salt had, neither in causing the straw to be stronger and stand up better, nor in hastening the process of ripening; nor did the men employed in reaping the crop detect any difference in the quality of the straw from that on the adjoining ridges, pieces of the crop being about equally lodged in them all. The soil in this case was mostly a stiffish clay, also naturally wet, but thoroughly drained.

The crops along the sea-coast may be observed in many places to be generally earlier in ripening than those farther inland; and it is possible that this may be partly due to the greater quantity of sea-salt brought up on them by the winds off the ocean.

"Fresh-fallen rain," says Mr. Mallet, in investigating the action of air and water on iron, "after a time of drought, especially in cities, comes down so loaded with free oxygen, carbonic acid, and ammoniacal salts, that it produces instantly a coat of red rust upon any iron placed in contact with it." He then gives the following interesting effect of dew:—"But the deposition of dew, under certain circumstances, originates the most immediate and powerful oxidation, as the following observation testifies: On the 14th March, 1842, the temperature at Dublin, at twelve o'clock noon, was high, and the day fine, but the air was nearly saturated with moisture, and dew rapidly collected on the polished parts of a large steam-engine, which stood unfinished in a shady open building whose temperature was considerably below that of the open air. In two hours' time after being wiped clean with cotton-waste, all its bright-work had a moist coating of red rust upon it. The rusty moisture could be swept off by the finger. The fact of such rapid action of deposited dew is remarkable, and is not confined to a single instance, having been noticed also to me by engineers as occurring frequently at Liverpool."

The yearly amount of rain that falls in the British Islands has been computed to be (*Johnston's Physical Atlas*, folio ed.):—

	English Inches.
On plains	24·51
On mountain ranges	40·59

Taking the ammonia that occurs in rain-water at the mean found by Lawes and Gilbert, viz., about 1 grain in 1,000,000 of rain-water, we should have brought down upon the plains of Britain a yearly amount per imperial acre of 5·544 lbs. avoirdupois of ammonia; and supposing further that the nitric acid brought down in the rain here bears the same ratio to the ammonia as has been found by Barral at Paris (viz., as 16·25 to 3·49), we should have annually furnished to the land by rain—

	lbs. avoirdupois.		lbs. avoirdupois.
Ammonia	5·544	= nitrogen	4·565
Nitric acid	25·814	= ditto ..	6·693
Total nitrogen in rain per acre ..			11·258

Mr. Lawes gives as the mean result for the monthly amount of ammonia in rain, at Rothamsted, per acre, half a pound, which would be just 6 lbs. of ammonia in the year, being rather more than the above statement, arising doubtless from the quantity of rain at Rothamsted being, during his experiments, greater than what I have taken the average fall to be.

The quantity of rain that fell at Paris during Barral's experiments seems to have been a good deal less than usual; he gives the average monthly amount of ammonia per acre at 0·81 lbs., which would be 9·72 in the year. On an average of thirty years it has been found that the mean annual fall of rain at Paris is 26·6 inches. Supposing then that the proportions of ammonia and nitric acid were to be the same for this quantity as Barral found them to be during the five months of his observations, the result per imperial acre in rain at Paris would be—

	lbs.		lbs.
Ammonia	21·061	= nitrogen	17·344
Nitric acid	97·785	= ditto ..	25·352
Total annual nitrogen in the rain ..			42·696

As, however, it is generally noticed, that after some continuance of rain the proportion of ammonia gets less, it is not perhaps probable that quite so much would be conveyed in a year to the ground.

The annual fall of rain in Alsace, where Boussingault experimented, may be taken as the same as at Paris. He found, during observations of six months, March to August inclusive, 0·744 in 1,000,000 of rain; taking the nitric acid in the same ratio as at Paris, we get in the rain per acre:—

	lbs.		lbs.
Ammonia	4·477	= nitrogen	3·687
Nitric acid	20·846	= ditto ..	5·405
Total nitrogen per acre			9·092

The above calculations have, therefore, given the total amount of nitrogen per acre brought down to the ground in a year in the rain-water as under:—

	lbs. avoirdupois.
Average of Britain (low grounds)	11·258
Alsace	9·092
Paris	42·696

It will be seen, therefore, how largely the soils in the neighbourhood of cities must be benefited by the manurial substances brought down in the rain, if there is any confidence to be placed in these figures.* It must, however, be borne in mind that these observations have been carried on but for very limited periods, and also that the means at present existing for determining the very minute quantities of these substances in the rain are not very satisfactory; indeed, with regard to the nitric acid, Mr. Lawes, in a communication which he has favoured me with on the subject, states that, in the opinion of the most eminent chemists, it is doubtful whether there is any process known by which the very small proportions of that ingredient can be accurately determined. It may be interesting, however, to compare these results with the quantities of nitrogen found in the crops commonly grown in this country: a table, therefore, from Dr. Anderson, of Glasgow, is subjoined, showing the amount of nitrogen in pounds contained in average crops per imperial acre of the plants usually cultivated here:—

	In the Grain.	In the Straw.	Total.
Wheat	38	16	54
Barley	36	8	44
Oats	60	14	74
Beans	80	35	115
Peas	75	60	135
Turnip	76 bulbs	50 tops	126
Potato	81 tubers	24 tops	105
Meadow-hay	..	..	57
Red clover	..	..	74
Flax	44	16	60
Rye-grass	..	..	68

It will be seen therefore that, according to the figures before given, it is possible the rain in the precincts of a large city like

* Since the above was written Mr. Way has published the results of an examination of the rain-water collected at Rothamsted in 1855, according to an improved mode of analysis, by which he found that the amount of nitric acid was very much less than what Barral's results had led us to expect; that indeed it contributed far less nitrogen than the ammonia. The latter, however, he found in greater quantity than Mr. Lawes had previously done, reaching to the amount of 7·11 lbs. per acre in the year, and in the proportion of 1·228 parts in a million of water.

Paris may bring down as much nitrogen as is contained in the grain of an average crop of barley or wheat. As it must be supposed that a good deal of ammonia and nitric acid will be absorbed by the soil from the atmosphere, in addition to what is brought down by rain, it appears quite conceivable that under favourable circumstances the soil and plants growing upon it may obtain as much *nitrogen* from the atmosphere as will suffice for many of the crops usually grown, without the agency of other manure—a supposition which the results obtained by the Rev. Mr. Smith, at Lois-Weedon, tend to justify. And the above calculations would also point to the propriety of employing mostly mineral manures in the immediate neighbourhood of large towns, trusting to the atmosphere supplying the greater part of the necessary nitrogen and carbonic acid.

Rain-water then, in its percolation through the earth, by virtue of the oxygen which it holds condensed, eminently favours the oxidation of the mineral and organic matters of the soil; the former, in consequence of this process, is brought into partial decomposition, for a stone, says Dr. MacCulloch, is generally disintegrated by the oxidation of the iron it contains, while the latter, or the organic matter, is thereby made to pass through the various stages of decay, evolving in the process much carbonic acid and also ammonia. The rain also, by virtue of the carbonic acid, ammonia, nitric acid, and salts, which it holds in solution, dissolves gradually the mineral substances of the soil, and enables them thereby to be taken up by the roots of plants, and it also furnishes directly in itself much nitrogen in a form fit for being assimilated by the vegetable organism, and it may further probably supply sensible quantities of salts of lime, magnesia, potass, soda, &c., which are taken up by the action of the wind from the waters of the sea.

This would seem to be the fittest place to take some notice of the

Absorptive Properties of Soils.—The absorbent powers of the ingredients of the soil depend both upon the kind of matter of which it is constituted, and also upon the physical and mechanical conditions under which that matter exists. As regards the absorption of gaseous substances, the quantity taken up will depend in a great measure upon the amount of surface with which the body to be absorbed can come in contact. Thus anything that tends to solidify the soil, or bring its particles together into a compact mass, will obstruct its powers in this direction; and on the other hand, the more porous and finely comminuted the soil is made, the more surface will be brought to bear upon the gaseous matter. Thus Mitscherlich calculates that a volume of one cubic inch filled with globules not exceeding $\frac{1}{10,000,000}$th of an inch in

diameter, but arranged so that lines passing through their centres are mutually perpendicular or parallel, will present a surface of 218,166 square feet, and he considers that the substance called platinum black (platinum in a degree of exceedingly fine separation), may possibly offer a surface of this extent. The cells of charred wood are, on an average, $\frac{1}{1200}$th of an inch in diameter, according to the same high authority, and its surface for a cube inch would therefore by calculation be equal to 100 square feet, supposing the charcoal itself to occupy no space. He however found, by immersing a piece of charcoal in water, that only $\frac{5}{8}$ of its entire volume are left available for the entrance of gases, which would give a surface of 73 square feet. Now, as Saussure found that charcoal absorbed 35 times its volume of carbonic acid at 53°·6 F., and at a pressure of 26·895, these 35 volumes of carbonic acid are contained in the space which forms $\frac{5}{8}$ of the total volume of the charcoal, and consequently 56 times less than the space originally occupied by the carbonic acid.

But, according to the experiments of M. Addami, carbonic acid becomes liquid at a pressure of 36·7 atmospheres, the temperature being 53°·6 F.; we are therefore led to conclude, says Mitscherlich, that more than one-third of the carbonic acid condensed in the pores of the charcoal is in a liquid state on the walls of the cells. (*Mitscherlich, Ann. de Chim. et de Phys.*, 1843.) Ammoniacal gas, which liquefies under much less pressure, is absorbed in far greater degree.

All porous bodies which offer a considerable surface to gases act like charcoal. The humus of the soil and decayed wood approach very nearly to charcoal in this property—decayed oak-wood, according to Liebig, absorbing 72 times its volume of ammoniacal gas after having been completely dried in the air-pump. Platinum black, prepared by Davy's method, surpasses all other known substances in this property, 10 grains, according to Dobereiner, condense 0·550 cube inch of oxygen, that is to say, one cube inch would condense 253,440 cube inches.

The property which some bodies, such as silica, possess of condensing the humidity of the air, may authorize us, says Mitscherlich, to conclude that they are adapted for condensing gases; for in the same manner that solid bodies attract gases, so are they also capable of exercising this attraction upon liquid bodies.

It will be seen, therefore, how important a matter, even in this respect alone, it is to work the soil when it is in a suitable state for crumbling down and pulverizing under the action of the plough or other implement used, and not to turn it over in a wet clammy condition, when it sticks together or glazes over in continuous solid lumps. The disintegrating effect of the frost upon it will be also appreciated.

The following, from Saussure, shows the absorptive power of boxwood charcoal on some gases:—

1 volume of charcoal absorbs of—

	Volumes.
Ammoniacal gas	90
Sulphuretted hydrogen	55
Carbonic acid	35
Olefiant gas	35
Carbonic oxide	9·42
Oxygen	9·25
Nitrogen	7·5
Hydrogen	1·75

The following table, from Schubler, will give some idea of the relative absorptive properties of different kinds of earth:—

	Moisture absorbed by 1000 grains of dry Earth on a surface of 50 square inches in 72 hours.	Oxygen absorbed by 1000 grains of moist Earth in 30 days from 15 cubic inches of Air.
	Grains.	Per Cent.
Siliceous sand	0	1·6
Gypsum powder	1	2·7
Calcareous sand	3	5·6
Arable soil	23	16·2
Sandy clay	28	9·3
Slaty marl	33	11·0
Loamy clay	35	11·0
Fine lime	35	10·8
Stiff clay	41	13·6
Grey pure clay	49	15·3
Garden mould	52	18·0
Fine magnesia	82	17·0
Humus	120	20·3

None of these earths absorbed any oxygen when in a perfectly dry state. It will be remarked how nearly the same the order is in which they absorb these two substances.

With regard to the property of the earth to suck in moisture, oxygen, ammonia, and other gases, the humus or organic matter of the soil is found to have a more powerful effect than any other ingredient, although clay, oxide of iron, and magnesia, are also great absorbers; for it is found that if a portion of earth is burnt and its humus thus volatilized, while the oxide of iron is raised to a higher degree of oxidation, its power of absorbing oxygen becomes considerably diminished, and, according to Schubler, in some instances disappears; and Way found in his experiments that the power of a soil to combine with ammonia, filtered through it in solution, was greatly diminished by burning it, and that the more strongly the soils were burnt the more completely was their absorptive power destroyed, whether they had previously contained

vegetable matter or not. The following results obtained by Leslie clearly show this effect in regard to several bodies :—

Kinds of Earth thoroughly Dried.	Degrees of Moisture absorbed from Air at about 60° Fahr.
Clay very highly torrefied	8
" strongly roasted	35
Pipe-clay	85
Silica very highly torrefied	19
" soaked in water and dried after high torrefaction	35
" in its natural state	40
Whinstone very highly torrefied	23
" in its natural state	80
" in a crumbling state	86
" reduced to mould	92
Carbonate of lime	70
Shelly sea-sand	70
Sea-sand from a sheep-walk	78
" cultivated	85
Carbonate of magnesia	75
Alumina	84
Garden mould	95

The substances were dried thoroughly and introduced immediately into a phial with a close stopper; the powder having undergone that preparation was thrown into a very large wide-shaped bottle, and shut up till it had attracted its share of humidity from the confined air; a delicate hygrometer being now let down into the bottle indicated the measure of the effect produced by absorption. (*Leslie on Heat and Moisture.*) Leslie looked upon this power as exactly analogous to that of the concentrated acids and deliquescent salts.

As the greater the power of a soil to contain water, the more has it, in general, the property of absorbing moisture when dry, and gaseous matter when in a moist state, from the air, I have extracted the following results from the examination of German soils by Geiger, Sprengel, and Schubler, in regard to their power of containing water, and have arranged them in a tabular form (p. 451), so that the facts contained in it may more readily catch the eye.

It will be seen, therefore, from all the results shown in the Table, that this power of absorbing moisture, oxygen, and probably other gases, is most highly developed in humus; that clay also stands high in the list; and that siliceous or quartz sand is very clearly deficient in this respect;—that much moreover depends upon the mechanical condition, for whatever tends to reduce the substance to a state of fine division exalts the absorbent power. Davy, for instance, found that 1000 grains of *coarse* sand, dried at 212° F., absorbed from a moist atmosphere only eight grains of moisture, whereas the like quantity of *fine* sand, under the same treatment,

	Percentage. Humus and Volatile Matter.	Sand.	Clay.	Lime and Calcareous Sand.	Alumina.	Power of containing Water.
Vineyard soil	3·3	much	little	..	..	20·
Sterile sandy	4·2	88·	..	..	..	25·
Vineyard soil	8·	66·5	some	19·	..	35·5
Very fertile arable	11·2	64·8	..	9·7	5·7	35·7
Vineyard soil	5·5	54·	37·	9·	..	37·
Sandy soil, pine forest ..	1·3	77·	20·1	some	..	38·2
Superior vineyard soil ..	5·6	60·	24·4	12·7	..	40·7
Vineyard soil	8·8	44·	56·	0·4	..	42·
Fertile arable soil	5·7	28·8	62·	3·4	..	46·7
Ditto	5·	83·3	..	1·8	5·1	49·2
					Oxide of Iron.	
Sterile clay soil	4·4	77·8	..	none	8.1	49·2
Fertile arable soil	7·8	25·2	70·6	1·2	..	50·
Vineyard soil	7·	50·	46·	3·	..	53·
Fertile arable soil	9·8	17·2	64·7	16·4	..	61·3
Ditto	5·6	17·3	63·6	4·1	..	67·2
Good meadow-land	4·5	46·	46·7	3·	..	78·1
Ditto	6·3	20·8	48·	29·6	..	85·
Very fertile black soil ..	17·7	1·2	47·	33·8	..	91·6
Light garden-mould	18·6	much	remainder	1·6	..	100·
Ditto	21·	remainder		15·5	..	106·
Very light soil	8·4	10·8	42·7	38·	..	124·
Vegetable garden-mould ..	30·	remainder		11·	..	155·
Black sterile turf	76·	..	..	..	..	179·
Vegetable leaf soil	33·	remainder		16·	..	203·
Wood soil from decayed trees	47·	remainder		10·	..	210·
Very light sterile brown turf	89·	..	..	..	..	366·

took up eleven grains. As regards the humus, its absorbent power would appear to vary according to its origin, Schubler having found that derived from vegetable substances inferior in this respect to the humus arising from the decay of animal matter. It would seem, then, that this property of absorbing gases and vapours from the *atmosphere*, which must not be confounded with the property of removing substances in solution by means of filtration, is probably similar in its nature to the power of condensing substances within them which has been long known to reside in porous or finely divided bodies, such as charcoal or platinum black.

With regard to the comparative extent to which this power may reside in old and newly-raised soils, I think there can be little doubt that long-cultivated dry soil, highly charged as it generally is with humus, and having its particles continually pulverized by the operations of tillage and the roots of plants, will greatly exceed in this respect raw, newly-raised soils which have long lain in a dead compact state beneath the furrow. The

ferruginous earths that frequently abound in some subsoils will, however, on exposure to the atmosphere, take up ammonia to a considerable degree after they have crumbled down under the influences of frost, rains, and drought.

This power of drawing in the ammonia is so important and interesting, now when that substance has been demonstrated to be always present in the air, that some farther consideration of it seems here necessary. It has been seen that ammonia is taken up by porous bodies, and by water, to an extent greatly exceeding the other gases; it may therefore be expected that the soil will likely be able to condense a considerable quantity of it within its pores, for ammonia, being a highly condensible gas, is absorbed by solid bodies in much larger proportions than air or oxygen.

Faraday made some interesting researches on this subject owing to certain remarkable statements made by Reiset, who had obtained ammonia from substances which were quite destitute of nitrogen, and who had assumed that the nitrogen of the air contained in their pores was the source of this formation of ammonia.

Faraday found that white clay from Cornwall, after being heated to redness and exposed for a week to the air, yielded ammonia abundantly when heated in a tube; and that sea-sand heated to redness in a crucible and allowed to cool on a plate of copper, on being afterwards shaken upon the hand and stirred about there for a few moments with the fingers, was found to contain ammonia in very appreciable quantity. Some asbestus, in like manner, heated to redness and afterwards simply pressed with the finger, yielded indications of ammonia when heated in a tube. Faraday also ascertained that fused potash had the power of absorbing ammonia from the air; and, in short, that the strange results of Reiset arose from this overlooked property of many bodies greedily absorbing ammonia from the atmosphere. (*Quarterly Journal of Science*, vol. xix.)

Bouis showed that the peculiar odour observed on moistening minerals containing alumina is partly owing to their exhaling ammonia. Boussingault states that the ferruginous earths in the primitive rocks of South America yield ammonia on being heated, and Berzelius found the same to be the case in those of Sweden; and Braconnot has shown that most basalts, trap, granite, syenite, hornblende rock, and many other minerals, yield by dry distillation water containing a sensible quantity of ammonia. Soils, therefore, derived from such minerals will absorb a good deal of ammonia, even although they do not contain much organic matter.

Whinstone, which is a Scotch term for greenstone and other

like varieties of trap rock, it will be remembered, was found by Leslie, when reduced to a state of mould, to stand next to garden-mould in its power of absorbing moisture. Oxide of iron, which occurs in large quantities in these minerals, has been found by all investigations to have a great attraction for ammonia.

If, therefore, the earth contains much humus, alumina or clay, oxide of iron, or magnesia, in a state of fine division, its power of absorbing gaseous matters from the air will probably be good.

Rose has also observed that some sulphates possess the property of absorbing ammonia and of forming with it definite compounds, which, unlike the sulphates of ammonia prepared in the moist way, contain no water of crystallization, and easily give out again the ammonia contained in them. They are formed by placing the anhydrous sulphate in a glass tube, and transmitting over it at common temperatures ammoniacal gas, well dried by fused potassa, as long as any increase of weight is observed; some sulphates absorb the gas very rapidly at first, and with disengagement of heat, but the absorption afterwards becomes slow, and requires a day or two to be complete. The salts most remarkable for this property are those which in solution are disposed to unite with ammonia. This, it will be observed, is quite a different property from the mere condensation of the gas within a porous body; here there would appear to be some chemical action.

Rose compares these compounds to hydrates: water acts as a feeble base to saline compounds, combining with some in one or more proportions, and not at all with others, differing greatly in the ratio in which it combines with different salts, and being abandoned with great facility. The same features characterize the combination of ammonia with the anhydrous sulphates. (*Pog. Annalen*, xx. 149.)

Rose also found that sulphates are not the only salts which absorb ammonia; some nitrates also possess that property, and the nitrate of the oxide of silver absorbs it with such rapidity, and the corresponding increase of temperature is so great, that the salt enters into fusion.

Relating as this paper does to the action of the atmosphere, the power of soils to combine with and remove substances from solution seems less connected with its object;* and as Professor Way has so fully treated the matter in recent numbers of the Journal, there is less occasion for here touching upon it. Some of the results arrived at may, however, be alluded to. "Soils were found to possess," says Way, "in a greater or less

* This remarkable property was observed by Mr. H. S. Thompson in 1845; and the subject has since been perseveringly followed by Mr. Way.

degree, the power of removing from solution in water certain animal and vegetable substances, but still more the alkaline bases ammonia and potash, and the earths magnesia and lime. These bases the soils were capable of separating from their salts, and retaining more or less, in spite of the action of water." And experimenting upon silicates artificially prepared, the same chemist found that ammonia could be removed by soils from solution in water in virtue of their containing either the double lime or the double soda silicate—the two double silicates supposed to be most usually present—whereas it was found that the lime salt alone was capable of removing ammonia from its atmospheric solvent. Professor Way, therefore, concluded that to these double silicates this power of absorbing and combining with substances from solution is probably due.

I may here insert the following short table, extracted from some of Way's experiments, and which should have come in at a previous page. It shows the amount of ammonia absorbed by 1000 grains of different kinds of soils, exposed on a sheet of paper to a moist atmosphere charged with carbonate of ammonia:—

	Gravelly Soil 4 feet below the Surface.	Gault Clay after Trenching.	Gault Clay 4 feet deep.	Top Soil of London Clay, 48·90 per cent. of Sand.	London Clay, 2 feet deep, 21·95 per cent. of Sand.	London Clay, 3½ feet deep.
Ammonia in 1000 grains of natural soil	0·110	0·127	0·083	0·293	0·182	0·085
Ammonia in 1000 grains of soil after exposure to atmosphere of ammonia ..	1·097	2·615	2·028	1·906	2·557	3·286
Amount of ammonia absorbed	0·987	2·488	1·945	1·613	2·375	3·201

It will be observed in the three last columns that in the case of the London clay the under soil absorbed more ammonia than the surface—a result apparently adverse to the opinion which I expressed, that the surface-soil would be a better absorber than the subsoil; but in this case the result is evidently owing to the much less amount of sand found below, and probably has nothing to do with the amount of humus or organic matter; sand being, as has been abundantly shown, a very bad absorber.

Action of Organic Acids.—The effect of these upon the soil in hastening the decomposition and dissolution of the mineral matter is probably sometimes considerable; they may be considered as originating from the influence of the oxygen of the air upon the carbonaceous matters of the soil, and therefore any effects produced by them may be viewed as indirectly proceeding

from the atmosphere. The bleached and whitened appearance of stones that have lain amongst peat is familiar to many; this may be supposed to arise from the acids of the peat dissolving out the iron or colouring-matter of the mineral.

Professor Johnston, of Durham, drew some attention to this action of the organic acids in a communication to the British Association, without however doing much to the elucidation of the subject; he adduced the instance of the mineral pigotite, formed in the caves of Cornwall by water dripping from the roof. This water contains a peculiar organic acid, derived from the soil of the moors, which dissolves the alumina of the granite and combines with it. Scarcely anything, however, appears to be known about the matter, and it therefore need not longer detain us.

As the nature of the changes wrought upon the various oxides and earthy salts of which the soil is composed must depend greatly upon the constitution of the mixture of mineral substances from which this earthy matter has been derived, it will be proper to examine some of the geological and mineralogical features which the surface of this country presents.

It is found that the whole of Scotland, and the north and middle divisions of England and Ireland, with the exception of the higher hills, are covered more or less deeply with a superficial deposit of clay, gravel, and loam (containing in many places large blocks and stones), out of which the agricultural soil of the country is derived. This soil consists of the débris of minerals in a greater or less state of disintegration, together with fragments of undecomposed minerals and a variable amount of organic matter. The soil, therefore, is generally just the subsoil *plus* organic matter. This organic substance, or earthy mould, is chiefly carbonaceous material derived from the decay of vegetable and animal bodies.

The superficial deposit to which I have adverted is known geologically by various names: as the northern drift, boulder formation, erratic tertiaries, diluvium, and till; and recent investigation has demonstrated that at the time of its deposition the land now covered by it was submerged below a glacial or icy sea, above which rose the summits of our highest hills in the shape of islands.* The physical conditions of this area have been thought very similar to those that at present prevail on the north-eastern coasts of America, within the line of summer floating ice. The limits of the region have not everywhere been ascertained, but the late Professor Edward Forbes draws the boundary across

* It will be seen that I am speaking here in a general sense. Many river-valleys contain superficial accumulations newer than the drift; and in other localities it may not always occupy the surface. The phenomena of ice, also, may not have prevailed during the whole time of its deposition.

the southern half of Ireland and England, continuing it eastward so as to strike against the Ural chain of Russia; thus including almost the whole of Central and Northern Europe. (*Mem. of Geological Survey*, i. 351.) This elevated sea-bottom, then, now presents itself in the form of great sheets of clay, gravel, sand, mud, and loamy earth, either stratified or unstratified, with here and there the subjacent rock peeping through. It varies greatly in different localities both as to quality and thickness, and occupies all altitudes, from the sea-level up to 1400 or 1500 feet, the clays and marls being generally inferior to the gravels. This mass in any one locality is in general mainly derived from the rocks in the quarter of the country where it is situated, but contains often a multitude of miscellaneous materials which have come frequently from a great distance, and that from a north direction, or from points to the east or west of north. Thus, above the chalk rocks it may be chiefly composed of the débris of that formation; over the old red sandstone, chiefly of materials of the Devonian kind; over limestone mostly of calcareous matter; and, in the north of Scotland, in a great measure, of the component parts of the primary and trap rocks. But although in the south-eastern counties, such as Cambridge, Suffolk, Essex, &c., there will be often many fragments whose source must be looked for in the far north, amongst the hills perhaps of Northumberland or Inverness, yet we never find materials from the middle of England in the north; never, for instance, boulders of chalk in the till of Perthshire.

Although in some places no foreign matter is to be met with, yet we find this heterogeneous mixture extending south as far as even the suburbs of London; but beyond the metropolis, in Surrey, Kent, Sussex, and other parts of the southern division of the kingdom, the boulder clay is wanting; and although superficial deposits are to be met with in parts of even the southernmost counties, yet they seem less general and of a different character, and in many districts the soil seems to be derived immediately from the subjacent rock.

We have, therefore, in Britain the greater portion of the surface occupied with this mixed deposit, and a comparatively small area in the south without it. This latter portion may have probably been in part land during the glacial epoch, and it is only in it that we may with some greater degree of certainty expect to find the arable soil characteristic of the rocks which lie immediately below it. Fortunately part of this area has been explored by the Geological Survey, and the results given to the public. Accordingly, we find Sir Henry De la Beche, in speaking of the surface of Cornwall, Devon, and West Somerset, say—"The fertility of the district is found to vary most materially, and, taking the geological map in our hand, we ascertain that this

variation coincides very generally with the boundary-lines of the different formations; so that, if the scale be sufficiently large, the relative fertility may, in some cases, be traced even across fields, portions of them being far more productive than others."

Although the varieties of geological strata are almost endless, yet they are found to be, for the most part, ultimately derived from a few kinds of simple minerals, such as quartz or silica, felspar, mica, hornblende, limestone, &c.; and the best way to serve the purposes of this paper seems to be to take up each of these in succession, and show how it is affected by the atmospheric influences. To save space, their chemical composition, derived from the examination of the best analysts, is given together in one Table.

Minerals.	Authority.	Silica.	Alumina.	Magnesia.	Lime.	Potash.	Soda.	Peroxide of Iron.	Protoxide of Iron.	Fluoric acid and oxide of Manganese.	Water.
Quartz	Rose	97·50	0·25	. .	. .	. .	. .	0·50	. .	0·25	. .
Felspar, orthoclase	Klaproth	64·50	19·75	. .	trace	11·50	. .	1·75	. .	. .	0·75
„ albite	G. Rose	68·46	19·30	trace	0·68	. .	9·12	0·28	. .	. .	. .
„ labradorite	Klaproth	55·75	26·50	. .	11·00	. .	4·00	1·25	. .	. .	0·50
„ oligoclase	Berzelius	63·70	23 93	0·65	2·05	1·20	8·11	0·50	. .	. .	. .
Compact felspar	Klaproth	73·50	15·00	. .	1·00	6·50	. .	1·50	. .	trace	0·75
Mica, potash	H. Rose	46·10	31·60	. .	. .	8·39	. .	8·65	. .	2·52	1·00
„ lithia	Turner	50·82	21·33	. .	. .	9·86	. .	. .	9·08	4·81	(Lithia) 4·05
„ magnesia	H. Rose	42·01	16·05	25·97	. .	7·55	. .	4·93	. .	0·68	. .
Chlorite	Von Kobell	26·51	21·81	22·83	. .	. .	. .	. .	15·00	. .	12·00
Talc	Berthier	58·20	. .	32·20	. .	. .	. .	. .	4·60	. .	3·50
Steatite	Lychnell	64·53	. .	27·70	. .	. .	. .	. .	6·85	. .	. .
Serpentine	Rammelsberg	43·79	. .	41·03	. .	. .	. .	. .	2 05	. .	12·47
Hornblende, common	Bonsdorff	48·83	7·48	13·61	10·16	. .	. .	. .	18·75	1·56	0·50
„ basaltic	„	42·24	13·92	13·74	12·24	. .	. .	. .	14·59	0·33	. .
„ „ decomposed	Madrell	44·03	14·31	2·33	10·08	. .	. .	25·55	. .	. .	3·44
„ tremolite	Bonsdorff	47·21	13·94	21·86	12·73	. .	. .	. .	2·28	1·47	0·44
„ actinolite	„	59·75	. .	21·10	14·25	. .	. .	. .	3·95	1·07	. .
„ asbestus	Rammelsberg	57·98	0·58	22·38	12·95	. .	. .	. .	6·32	. .	. .
Augite, common	Kudernatsch	47·05	5·16	15·35	23·77	. .	. .	. .	7·57	. .	. .
„ decomposed	Rammelsberg	45·87	11·18	0·28	1·50	(alkali) 6·72		. .	24·63	. .	9·92
„ „	„	39·48	10·81	1·70	carb. of lime. 15·24	alkali and water 8·67		8·94	15·66	. .	. .
„ „	„	85·34	1·58	1·70	2·66	. .	. .	1·67	. .	. .	5·47
„ „	„	60·63	23·09	0·91	1·28	. .	. .	4·21	. .	. .	9·12
„ sahlite	H. Rose	54·86	0·21	16·49	23·57	. .	. .	. .	4·44	0·42	. .
„ „	Berzelins	50·00	. .	4·50	20·00	. .	. .	. .	18·85	3·00	0·90
Diallage	Regnault	50·05	2·58	17·24	15·63	. .	. .	. .	11·98	. .	2·13
Epidote, common	Rammelsberg	37·98	20 78	1·11	23·74	. .	. .	17·24	. .	. .	. .
Olivine	Berzelius	40·86	. .	47·35	. .	. .	. .	. .	11·72	0·43	. .
Kaolin	Berthier	46·80	37·30	trace	. .	2·5	. .	. .	. .	. .	13·0
Greenearth	Klaproth	51·50	. .	1·50	. .	18·00	. .	20·50	. .	. .	8·00
„	Vauquelin	52·00	7·00	6·00	trace	7·50	. .	23·00	. .	trace	4·00
Glauconite	Turner	48·50	17·00	3·80	. .	. .	. .	. .	22·00	. .	7·00
Zeolite, analcime	Thompson	55·60	23·00	. .	. .	. .	14·63	. .	. .	. .	7·90
„ natrolite	„	48·04	25·03	. .	. .	. .	16·76	. .	. .	. .	9·65
„ scolezite	Berzelius	46·80	26·50	. .	9·87	. .	5·40	. .	. .	. .	12·30
„ apophyllite	„	52·38	. .	. .	24·98	5·37	. .	. .	. .	0·64	16·20
„ chabasite	Thompson	48·76	17·44	. .	10·47	1·55	. .	. .	. .	. .	21·72
Calcareous spar	Stromeyer	. .	. .	. .	56·15	. .	. .	0·15	. .	(carbonic acid) 43·70	
Dolomite	Klaproth	. .	. .	carb. of magnesia 25·00	carb. of lime 73·00	. .	. .	2·25	. .	. .	. .

The disintegration and changes brought about upon rocks and minerals are due both to chemical and mechanical causes, the latter being chiefly frosts, alternations of temperature, and attrition or friction. As the most widely-dispersed and abundant mineral body I shall commence with—

Quartz, which, when it is quite pure, is silica, a compound of the elements silicon and oxygen in the following proportions:—

Silicon	48·04
Oxygen	51·96
	100·00

In this state it can be hardly affected by the chemical agency of the atmosphere, being insoluble in acids except the fluoric; when finely powdered it is partly soluble in solution of potash; any wearing down of it must therefore be principally due to attrition and mechanical friction. Silica is, however, less abundant in this pure state than in combination with some of the earthy or alkaline bases forming silicates, in which it plays the part of a weak acid; and even when forming a mineral by itself it frequently contains an appreciable amount of oxides of iron or titanium, of lime, alumina, and other substances. Silica has been estimated by De la Beche to constitute 45 per cent. of the mineral crust of the globe (*Researches on Theoretical Geology*, p. 8); it is therefore worthy of some attention, the more so as it is a necessary ingredient in many plants, and also essential to some animals. Although in its pure crystalline state it is one of the most refractory substances, it is yet in some of its combinations clearly subject to the solvent effects of the atmosphere and rains, as it is found in the stems of our grain crops, and must therefore enter their rootlets in a liquid form. It is well known as in solution in some thermal springs. The Geysers of Iceland, it has been seen, contain 0·50 of silica in 1000 parts of their waters, and their siliceous deposits extend to half a mile in various directions, with a thickness of more than 12 feet. (Sir Geo. M'Kenzie, *Travels in Iceland*.) Professor Bunsen states that, in the waters of the great Geyser the silica is dissolved in the water by alkaline carbonates, and in the form of a hydrate; is not precipitated on cooling the water, and it is only on evaporation that it is deposited in the form of a thin film on the moistened sides of the vessel, where evaporation to dryness takes place, while the fluid is not rendered turbid by hydrated silica until the concentration is far advanced. Messrs. Paine and Way also, in their paper on the silica strata of the lower chalk, have shown that certain strata in England, at the base of the chalk formation, contain a large proportion of soluble silica, varying from 5 to 70 per cent., 60 per cent. being in some places quite common, asso-

ciated frequently with carbonate of lime; and that the soluble silica in these rocks is dissolved out with perfect ease by boiling them in solution of potash or soda; and they point out that soils derived from these strata are celebrated for their fine crops of wheat and the strength of the straw grown upon them.

Professor Fuchs has shown that silica exists in minerals in two conditions, a crystallized and an amorphous one, and that in the latter it is much more readily acted upon by solvents than in the former.

A communication was made to the Royal Society by Julius Jeffreys, to the effect that siliceous materials exposed to the action of steam at high temperature were partially consumed, and a siliceous crust deposited on several vessels placed in the upper part of the furnace, which crust was re-dissolved when again subjected to a hotter steam. (*Proceedings of Royal Soc.*, iv. 233.) Dr. Wollaston also had observed that steam under high pressure becomes a rapid solvent of alkaline silicates; and Dr. Turner found that glass exposed to the vapour issuing from a high-pressure engine was rapidly corroded, rock crystal remaining unchanged, and that the silica taken up was again deposited in a beautiful stalactitical form. (*Proceedings of Geolog. Soc.*, ii. 95.) Turner also showed that rain-water must have the power of dissolving silica by contrasting the chemical composition of felspar with that of the porcelain clay, or kaolin, which results from its decomposition, pointing out that the water had carried off in some way all the potass, and 8½ out of 12 proportions of silica, leaving all the alumina and the remainder of the silica untouched. (*Phil. Mag.* 1833, vol. iii. p. 20.) Dr. MacCulloch also found an interesting case of the artificial sublimation of silica by a strong heat, in which it was deposited in the state of fine crystals, but he was unable to reproduce the results. (*Trans. of Geological Soc.*, 1st series, ii. 275.)

When glass contains 70 per cent. of silica and 30 per cent. of potash or soda, it becomes soluble in boiling water, and may be spread over any surface like varnish, the solubility of it varying according to the proportion of the alkali it is combined with. When a silicate is dissolved in water it is easily decomposed by the addition of an acid, even the carbonic, which displaces it from the base with which it is united, leaving it free. The resulting precipitate of silica has a gelatinous appearance, and is to a certain extent soluble in even pure water; if this gelatinous substance, or hydrate of silica, is dried, it presents the appearance of a white powder, and loses altogether its solubility on being strongly heated. The decomposition of the silicates of the soil is therefore probably effected by the action of the carbonic acid, which has been shown to be so plentifully generated therein, and

in this manner it is likely assimilated by plants. Way has pointed out that ammonia displaces the other bases that may be in combination with silica, thus forming a silicate of ammonia, which is gradually soluble in water, and by whose decomposition the silica would be yielded in a state suitable for the organs of plants.

Silica, therefore, exists in the soil in several forms and combinations; under some of these it is little affected by the atmospheric influences, but under others it is susceptible of a gradual dissolution, slow it is true, but still perhaps sufficient in many cases for the wants of the cultivated plants. By depriving silica of its oxygen, through the agency of potassium, or of some powerful deoxidiser, its remaining element, silicon, is obtained—a dark brown substance, incapable as yet of further decomposition, and therefore reckoned amongst the simple or elementary bodies.

Flint, one of the varieties of quartz, is abundant in many English soils, being derived principally from the chalk formation; it often encloses organic remains, such as shells, sponges, and infusoria. The exterior coat of it is often white, containing, according to Vauquelin, 5 to 10 per cent. of carbonate of lime. The interior is silica, mixed with a varying proportion of lime, peroxide of iron, alumina, potash, and carbonaceous matter. Flint may be dissolved by steam of a high temperature.

Felspar is another of the most abundant ingredients of the crust of the earth, and as it is frequently one of the most rapidly decomposing minerals, the atmospheric modifications of the soil are often due in a great measure to its changes. There are four principal kinds of it, the orthoclase or potash felspar being the most common in the granitic and plutonic rocks, while the soda and lime species, albite, labradorite, and oligoclase, are more prevalent in the volcanic products; labradorite appearing to characterize the basaltic division of the volcanic rocks, and glassy felspar the trachytic division.

Orthoclase, or common felspar, may be looked upon as a combination of silicate of alumina with silicate of potash. These silicates, as they occur in nature, differ widely in the facility with which they are decomposed. "The granite of Corsica and the felspar of Carlsbad," says Liebig, "crumble into dust in a space of time during which the polished granite of the Bergstrasse does not even lose its lustre." In many places here* the granite may be seen for several feet down so decomposed that it may be dug with a spade, whilst the features of the colossal monuments of Egypt remain unchanged, although the storms of

* In the neighbourhood of Ellon, Aberdeenshire.

thirty centuries have beaten over them. The crumbling of granite seems almost always owing to the decomposition of the felspar, the silicate of potash dissolving out while the earthy silicate of alumina remains behind in combination with two atoms of water falling down into a white powder.

Although the decay of felspar is generally referred to the carbonic acid of the atmosphere and the solvent power of water containing that agent, it appears not improbable that the ammonia and nitric acid of the air may also have a share in producing this effect. Way has shown that the silicates have the property of absorbing ammonia, and that it displaces several of the other bases. It is true he found the natural silicates finely powdered did not combine with the ammonia of a solution of sal-ammoniac, but he observed that in these bodies artificially produced, the silicates of potash, soda, and lime, were all decomposed by ammonia: now, as the ammonia of the atmosphere is considered to be in the form of a carbonate, it may act with increased force by the carbonic acid seizing the base, such as lime or potash, while the ammonia combines with the silica, forming silicate of ammonia and carbonate of potash, soda, or lime, as the case may be, thus giving rise to a double decomposition:—

Silica——Carbonic acid.
Potash——Ammonia.

Both the new compounds being soluble would be gradually washed away, leaving the silicate of alumina behind. Be this however as it may, the felspar in the course of the changes brought about gradually loses its transparency and lustre, the surface becomes dull and earthy, and at length it falls down into a powder. This powder forms the kaolin or porcelain clay; its composition is somewhat variable, but approximates to—

Silica	47·2
Alumina	39·1
Water	13·7
	100·0

A little iron and lime generally remains, and frequently some potash or soda, according to what was the original constitution of the mineral, and the degree of completeness with which the alkalies have been washed out. The following Table (p. 462) contains analyses of some varieties of porcelain clay.

A comparison of these with the analyses given of felspar will at once show what has taken place. When the removal of the alkalies has been complete, or nearly so, a poor sterile clay will be the consequence, but it is rarely that the alkaline silicate is

	Near Halle.	St. Yvreux. Berthier.	Devon. Fownes.	Cornwall. Bosse.	Miessen. Forchammer.
Silica	71·42	46·8	47·20	39·55	46·46
Alumina	26·07	37·3	38·80	38·05	36·37
Peroxide of iron	1·93	..	..	..	..
Lime	0·13	..	0·24	..	1·47
Potash	0·45	2·5	1·76	..	..
Magnesia..	..	trace	..	1·45	..
Water	..	13·0	12·00	12·50	13·61
Insoluble matter and talc ..	..	..	..	8·70	..

altogether dissolved out. Forchammer considers that the yellow clay of Denmark consists of granite, the felspar of which has been altered, whilst its mica remains unchanged, its quartz forming the sand of the clay; while the blue clay results from syenite and greenstone, which have no mica. The clay derived from the potash felspar is wanting in lime, and not so favourable to vegetation as that from minerals which contain both lime and potash or soda. The red colour of the clay is owing to the presence of peroxide of iron. In the blue clays the colour would appear to be occasionally owing to carbonaceous matter acting on this peroxide and converting it back into the dark protoxide. Thus, below beds of peat, even in districts where the clay is otherwise red, a blue-coloured clay is usually found; and beneath vegetation red marls and sandstones are sometimes seen converted into a green or bluish-green colour, the carbonaceous matter abstracting part of the oxygen. (*De la Beche.*) An interesting instance of this occurred in the parish of Culsamond, in this county. In cutting a ditch about 8 feet below the surface, large quantities of bog-iron ore (hydrated oxide of iron) were found mixed with decayed oak wood. The mixture was of a beautiful light-blue colour in consequence of the action of the iron and vegetable matter on each other. (*Stat. Account of Aberdeenshire*, p. 730.) Another instance was observed by the writer in his own house; during wet weather a little rain-water had come in at a skylight window, and trickling over a piece of rusty iron dropped upon a wooden floor. This water, impregnated with the iron rust (peroxide), gave the wood at first a brownish-red colour, but after a time the carbonaceous matter of the wood acting upon the iron abstracted part of the oxygen, and converted the spot into a dark-bluish green stain.

The shales and slate-clays of the sedimentary rocks may be viewed as arising in the same way as the other clays spoken of, viz. by the decomposition of felspar and other silicates. They will vary in fertility according to the amount of alkalies that remain in them; they are also often impregnated with foreign matters, bitumen, organic remains, &c.

The felspar seems to give way often more readily than even horneblende; thus I have in my possession specimens of syenitic greenstone, struck off the outside of a large weather-worn boulder, having the surface covered with protuberances of horneblende, the felspar that originally lay between having been all decomposed and washed away by the rains; and tracts of rotten granite, as has been said, are of not unfrequent occurrence in this quarter, decayed into an earthy gravel, apparently by the loosening of the felspathic paste in which the crystals of quartz are imbedded. This stuff is much in request for garden walks, for which it is often well suited by its whiteness.

Mica.—The most common kind is the potash mica. Its chemical composition is very variable, but, according to L. Gmelin, approaches to three parts of silicate of alumina with one of silicate of potash, part of the potash being occasionally replaced by protoxide of iron or manganese, and the alumina by the peroxide of these metals. The lithia and magnesia micas are much less frequent. Mica is a common ingredient in granite, gneiss, and many slates and crystalline rocks, and is one of the most generally distributed minerals. It seems to decompose slowly, apparently owing to the small proportion of alkali it contains. Dr. Paris has remarked that the relative proportion of the mica would seem to have an effect upon the character of the soils derived from the granite in Cornwall, tending to render them less fertile, an observation which is confirmed by De la Beche. The action of the atmosphere upon it is apparently similar to what takes place in felspar, the ultimate result being a clay, the potash or magnesia dissolving out.

Of these three minerals—quartz, felspar, and mica—are composed all the granites, gneiss, mica-slate, quartz-rock, and many sandstones, conglomerates, and porphyries. Common granite is composed of—

Quartz	40·
Orthoclase felspar	40·
Mica	20·
	100·

—the proportions in gneiss being somewhat similar. Mica-slate is often almost wholly composed of mica, or of that substance and quartz; while quartz-rock and many sandstones are little else but impure varieties of quartz.

Chlorite, Talc, Steatite, Serpentine.—These are all members of the mica family, are abundant, widely-dispersed minerals, and agree in containing a large proportion of magnesia.

Chlorite is frequently found in granite, gneiss, porphyries, and

amygdaloids, sometimes replacing mica. Chlorite-slate forms many mountains in Scotland. The chemical composition of chlorite is somewhat various, but may be considered a combination of silicate of alumina and magnesia, with a variable amount of oxide of iron.

Talc, in combination with quartz and felspar, and also as talc-slate, is a rock of frequent occurrence in the primary districts of this country. *Steatite* is a different form of the same mineral, and is also thought to be occasionally a result of the decomposition of chlorite. In talc, as associated with other minerals in granite, &c., it would seem as if the magnesia, once disseminated through the mass, had been segregated from the mixture into a condition by itself. Both talc and steatite are mostly silicates of magnesia, the latter being sometimes in part replaced by oxide of iron.

Serpentine is a well-known and abundant mineral, occurring apparently both as a sedimentary deposit and as an igneous production; great dykes of it occur in many districts, sometimes running for leagues in one direction. By itself it often forms mountains, and also occurs in combination with other minerals; it is found both in England and in Scotland. It is also a silicate of magnesia, containing much water, and having some of the magnesia occasionally replaced by oxide of iron. The soil derived from the decomposition of these minerals is rather noticeable for its barrenness, frequently being tenacious of water, so that swamps and marshy places are common. This has been remarked by Sir H. De la Beche of the soil on the serpentine of Cornwall, which contrasts unfavourably with that derived from diallage rock, a mineral mass containing a good deal of lime and less magnesia. This wet nature of the serpentine soil is doubtless owing to the remarkable tenacity of the magnesia for moisture, Schubler having found that this substance far exceeded all the other earths in this property.

The Professors Rogers, in their experiments on the solvent action of water, found that when it contained carbonic acid, the magnesian silicates dissolved readily.

The oxide of iron is also another element of decay, as will be more fully shown when treating of horneblende. Serpentine, as well as many other rocks, also occasionally contains iron pyrites, or bisulphuret of iron—a mineral very apt to suffer decomposition by the action of the atmosphere, the sulphur separating while the iron is converted into the hydrated peroxide. Sulphuretted hydrogen is also an occasional production from the sulphur. It is likewise found that another change sometimes occurs in the pyrites, by the sulphur combining with oxygen to form sulphurous acid—a sulphate of iron being the consequence. This pyrites is

found in many slates, and indeed in all sorts of rocks, being often seen in its crystallized form of yellow cubes in common roofing-slate.

Horneblende, Augite, Diallage.—These minerals are all of the same family. Their chemical composition is very variable, but they may be viewed as silicates of magnesia and lime, these bases being replaced often to a considerable extent by protoxide of iron, and to a less degree by alumina and oxide of manganese. Horneblende generally contains more silica than augite; the latter mineral has also been thought not to occur in rocks containing free quartz or silica, whereas horneblende does.* Some mineralogists and geologists, therefore, would make two distinct divisions of rocks:—1, the *Horneblende* series, including syenite, diorite, and dioritic and red porphyries; 2, the *Augite* series, comprehending hypersthene rock, dolerite, nepheline, and augitic and leucite porphyries. The very near affinity, however, of these two minerals is shown by some experiments of Gustavus Rose, who, on fusing horneblende in a porcelain furnace, found that on cooling it assumed the appearance of augite; and hence some eminent mineralogists favour the opinion that the distinction between the two bodies arises merely from different modes of cooling, horneblende being the result of slow, and augite of rapid, cooling. Diallage and hypersthene may be considered merely as varieties of augite.

Most of the great series of igneous and volcanic rocks are composed of various combinations of felspar and horneblende or augite, with occasionally some quartz, calcareous spar, and zeolites. The horneblendic minerals differ from the felspars and micas generally by the large proportion of lime and oxide of iron they contain, and by the absence of potash and soda. The igneous rocks, therefore, which contain both felspar and horneblende, will, by their decomposition, form a much more fertile soil than what would arise from granite, gneiss, &c., which generally contain only one of these minerals; for the felspar will supply the potash or soda, in which the horneblende family is deficient, while the latter will contribute the lime, magnesia, and oxide of iron, which are for the most part wanting in common felspar.

The horneblende minerals are amongst the most abundant ingredients of our rocks. They are very liable to be acted upon by atmospheric influences, chiefly through the oxidation of the protoxide of iron, which they so abundantly contain. In the case of common horneblende, a rusty-brown powder gathers upon the surface in consequence of the peroxide of iron which is formed by the protoxide combining with the oxygen of the air, and eventually the mineral falls down into a brown ferruginous earth, the magnesia and lime being liberated while water is absorbed, and a

hydrate of the peroxide of iron is the result, in combination with silicate of alumina and such remainder of the lime and magnesia as may not have been washed away. The magnesia seems to disappear faster than the lime, as will be seen by comparing the analyses given of the fresh and the decomposed mineral in the table, and this might have been looked for from the results of the Professors Rogers' experiments, as they found that in water impregnated with carbonic acid, such as rain-water passing through the soil always is, carbonate of magnesia is much more soluble than carbonate of lime.

The changes that occur in augite seem more various, green earth being frequently the result, with different degrees of decomposition. Steatite, or soapstone, seems also to be occasionally a product of the decay of this mineral, and also of horneblende, the lime and oxide of iron giving place to an increased proportion of magnesia and water. Analyses are given in the table, showing different stages of decomposition of these minerals, which are interesting as indicating the changes that have taken place.

These igneous rocks, decomposing under atmospheric influences, form soils generally noted for their fertility. In addition to the ingredients already mentioned as entering into their composition, Dr. Fownes, by careful analyses, ascertained the presence of phosphoric acid in various rocks of igneous origin. He examined the porcelain-clay of Dartmoor, resulting from the disintegration of the granite of that district, also lavas, basalts, and trachytes; and from his researches he inferred that phosphoric acid is a very usual component part of volcanic rocks, and is a principal source of the remarkable fertility possessed by soils derived from their disintegration. (*Proceedings of Royal Soc.*, v. 508.)

Dr. Anderson, of Glasgow, in reference to the igneous masses, writes:—"Rocks of the greenstone type are divisible into two classes—the diorite and dolerite; the former a mixture of albite and horneblende, the latter of augite and labradorite, sometimes with considerable quantities of a sort of oligoclase, containing both soda and lime, and of different kinds of zeolitic minerals. Generally speaking, the soils produced from diorite are superior to those from dolerite; the albite which the former contains undergoes a rapid decomposition, and yields abundance of soda along with some potash, which is seldom altogether wanting, while the horneblende supplies both lime and magnesia. Dolerite, when composed entirely of augite and labrador, produces rather inferior soils; but when it contains oligoclase and zeolites, and comes under the head of basalt, its disintegration is the source of soils remarkable for their fertility; for these latter substances, undergoing rapid decomposition, furnish the plants with abundant supplies of alkalies and lime, while the more slowly decomposing

horneblende affords the necessary quantity of magnesia. In addition to these the basaltic are found to contain appreciable quantities of phosphoric acid, so that they are in a condition to yield the plant almost all its necessary constituents." (*Encycl. Brit.* 8th ed. vol. ii., *Agricult. Chemistry.*)

In Cornwall Sir H. De la Beche observed that these rocks supplied the most fertile soils in the district, so much so that when greatly disintegrated they are sometimes worked as marl-pits. At the Lizard, in the same county, the soil on the diallage rock and sienite was found to be amongst the most fertile, if not the most fertile, of the lands in that quarter, exhibiting an instance of the productiveness of a soil chiefly derived from the decomposition of the horneblende or diallage and felspar. The horneblende slate and rock at the same place is also extremely fertile. "As the rocks at the Lizard," says Sir Henry, "are all exposed to the same conditions, the contrast afforded by the varied fertility upon these mineral compounds is highly instructive and illustrative of the fact that soils do, all other things being equal, mainly depend on the subjacent rocks for their agricultural character."

The Trap hills of Skye and many of the Western Islands of Scotland I have observed to be often remarkable for the beautiful green pasture which clothes their steep sides, the short sweet herbage soon covering the decaying greenstone, which in many places crumbles down fast under the united influences of the frost and rain. Doubtless the dripping climate, raining three days out of every four, as the natives say, has an effect little short of irrigation upon the pasture; but allowing for all that, and for any difference of level, the contrast between these green islands of the west and the rugged heath-covered ribs of the primary and granitic giants of the Cairngorm type is too great to be accounted for otherwise than by the less favourably constituted chemical nature of the latter rocks.

The solvent action of the atmosphere and rains on these minerals is evinced by the fact of the outer portions of decayed trap having been found to contain scarcely any lime, while the central kernel which that influence had not reached held a large proportion. (Johnston, *Chemistry of Agriculture.*) The same writer also remarks having picked up a portion of decaying trap on the farm of Swanston, on the Pentland Hills, which contained 16 per cent. of carbonate of lime.

Zeolites.—The family of zeolites comprises a good many species of minerals which agree in this respect, that they are compounds of silica with generally two or more bases, and a certain considerable amount of water in a crystalline state. These minerals when powdered and digested with cold muriatic acid are converted into a gelatinous mass. Now as felspar, which is

anhydrous, is scarcely affected when so treated with cold muriatic acid for twenty-four hours, but is unable to resist the continued action of water saturated with carbonic acid, much more must these zeolitic minerals be dissolved by the same agent. (Liebig.) They are all therefore rapidly decomposable bodies, and, like the felspars, yield a clay, while alkalis are separated. They are also noticeable for the absence of magnesia and oxide of iron in their composition, and potash is a less frequent constituent than either lime or soda. They occur chiefly in the amygdaloidal cavities of rocks, and although they do not, like the felspar or horneblende, constitute the great mass of a rock, yet they are often pretty freely dispersed. Analyses are given of some of the most common species.

Green-earth, as has been remarked, is sometimes merely a stage in the decomposition of augite; it is, however, quite a common mineral in this country, occurring chiefly in trap rocks. Its chemical composition is very variable, as will be seen even from the two examples given in the table.

Olivine is a very frequent ingredient in many igneous rocks, although it does not form a large proportion of their mass, being disseminated through them mostly in the form of small grains. It is believed to be seldom absent in basalt, and its chemical composition is a silicate of magnesia and of protoxide of iron.

Glauconite resembles green-earth in colour, and in other respects. It is referred to chiefly on account of its being a common body in the greensand strata, the specimen of which the analysis by Dr. Turner is given being from that formation in England. It also varies much in composition, some containing much magnesia or potash; it generally, however, has a large amount of silica, protoxide of iron, and water.

Epidote is a mineral of frequent occurrence in many crystalline trap rocks and also in amygdaloids, not however forming a great part of the mass. Its chemical composition is silicate of lime and alumina, these bases being replaced by protoxide of iron or of manganese, and also by magnesia.

Carbonate of Lime.—This mineral is so abundant in the sedimentary rocks that in all formations from the newest pliocene to the oldest silurian almost every other bed contains more or less of it, some of the great groups of rocks being merely alternations of shales and limestones. It varies of course infinitely in purity, the carbonate of lime being mixed often with carbonate of magnesia, forming dolomite, or with clay, forming marl, and with quartz grains constituting calcareous sandstone, and occasionally with sulphate of lime, giving rise to gypsum. Oxides of iron may also be interspersed throughout the mass; also phosphoric or fluoric acids, and bitumen and carbon, as in the coal measures.

Many sandstones are merely grains of quartz cemented together by carbonate of lime. Many limestones again are but a mass of organic remains, such as shells or corals. The mountain limestone in England for hundreds of feet in depth often consists of little else but remains of encrinites, while the animal origin of the white chalk seems equally obvious, the white calcareous mud found around coral reefs, being when dried undistinguishable from common chalk. As many limestones are but remains of corals the composition of these bodies becomes a matter of interest. From many analyses of corals made at the Museum of Practical Geology they were found to contain:—

Carbonate of lime	from	82·	to	95·5	per cent.
Carbonate of magnesia ..	„	trace	„	7·24	„
Sulphate of lime	„	trace	„	2·76	„
Organic matter	„	3·	„	8·27	„

Silica, alumina, iron, phosphates and fluorides were also obtained. A little phosphoric acid has also been found in most limestones that have been analysed with sufficient care. Messrs. Paine and Way have also contributed a paper to the Journal in which they point out the presence of considerable quantities of phosphate of lime in the greensands above and below the gault. The green grains of the sand are shown to contain sometimes 20 per cent. of phosphoric acid and a large proportion of lime, &c., and Prof. Henslow stated in 1845 that "a stratum of greensand, although never more than a foot thick, occurred near the surface over many square miles in the vicinity of Cambridge, the pebbles in it yielding 61 per cent. of earthy phosphates. The greensand is a variable mixture of green grains with pure white particles of quartz, the latter forming the largest proportion. From the mean results of some careful analyses of oolitic limestones at the Museum of Geology, they were found to contain—

Water	from	0·13	to	1·59	per cent.
Silica	„	0·22	„	13·62	„
Protoxide of manganese ..	„	0·	„	1·68	„
„ of iron	„	0·	„	1·13	„
Peroxide of iron	„	0·	„	0·82	„
Alumina	„	0·	„	0·54	„
Lime	„	29·30	„	54·94	„
Magnesia	„	0·14	„	21·42	„
Soda	„	0·	„	0·44	„
Carbonic acid	„	36·08	„	46·59	„
Sulphuric acid	„	0·	„	0·12	„
Phosphoric acid	„	0·	„	a trace	„
Chlorine	„	0·	„	0·03	„

Those most liable to be affected by the atmosphere contained a

soluble salt of either lime or sodium, *e.g.* sulphate of lime or chloride of sodium. The most crystalline are the most durable. (*Mem. of Geological Survey*, ii. 701.) The principal effect of the atmosphere on calcareous matter is to dissolve it through the action of the rain-water containing carbonic acid. Carbonate of lime is but slightly soluble in pure water, but absorbing more carbonic acid it is converted into bicarbonate, which is soluble to a considerable extent. "In some very earthy limestones," says De la Beche, "the disappearance of the calcareous matter in the upper portion of the rock for many feet down is sometimes so complete, and the peroxidation of the iron so extensive, that a rusty-looking porous substance is all that is left." The remains of shells in such rocks are often also dissolved out, leaving only the empty spaces or casts. Lime appears to have the effect of decomposing some of the silicates by turning out the alkaline base and instead thereof entering itself into union with the silicic acid.* Soda may be liberated by this process, and also potash. It probably also decomposes in some similar manner the salts of organic acids.

Oxides of Iron.—Combinations of iron are so widely and generally dispersed in all rocks and soils that it would be a great omission to neglect taking some particular notice of them.

1. *Carbonate of Iron*, or Siderite.—Its chemical composition, when pure, is:—

Protoxide of iron	62·1
Carbonic acid	37·9
	100·0

but part of the iron is generally replaced to some extent by manganese, magnesia, or lime. It is soluble in acids with effervescence. Occurs in beds of great extent in the coal formation of this country, the clay ironstone and black-band being but impure varieties of this mineral, and from it most of the British iron is manufactured.

2. *Phosphate of Iron*, or Vivianite.—It is chemically a combination of phosphoric acid with oxide of iron and a considerable amount of water; easily soluble in acids. It is frequently found in the neighbourhood of decayed animal matter, occurs also in some peat mosses, forming a blue crust on the dried peats. It occasionally fills the interior of fossil shells, but is found also in some igneous rocks, and doubtless is a frequent product in the soil.

* According to G. Bischof, bicarbonate of lime and silicate of potash, when mixed together in solution, give rise to carbonate of potash and carbonate of lime, silica being liberated; and he states that this decomposition takes place in nature.

3. ***Bisulphuret of Iron,*** or Pyrites.—Composed of—

Iron	46·7
Sulphur	53·3
	100·0

It is a frequent body in all kinds of rocks, being produced both in igneous and sedimentary formations. Less soluble in acids than the preceding. It appears frequently to arise from the decomposition of organic matter in solutions of iron. Mr. Pepys found an interesting instance of this take place by the putrefaction of some dead mice in a solution of sulphate of iron, and Sir H. De la Beche gives another of its formation where a dog had fallen into a solution of iron, its body being found surrounded by bisulphuret of iron or iron pyrites. (*Geological Observer*, p. 600.) Its mode of decomposition has been already referred to in showing its decay to be a frequent cause of the disintegration of minerals.

4. *Magnetic Iron* is a combination of protoxide and peroxide of iron:—

Protoxide of iron	31·23	Iron	72·40
Peroxide of iron	68·77	Oxygen	27·60
	100·00		100·00

Soluble in hydrochloric acid. Occurs mostly in igneous or metamorphic rocks, but also in beds and masses, chiefly in the northern parts of the globe, being the most important ore of iron in Sweden and Russia. It changes into oxyhydrate of iron and also into peroxide.

5. *Hæmatite,* or specular iron.—It is mostly peroxide of iron, and is slowly soluble in acids:—

Iron	70·03
Oxygen	29·97
	100·00

It is a very plentiful substance, and is occasionally produced by the gradual change of the carbonate and sulphuret of iron.

6. *Brown Hæmatite,* or Limonite, is a peroxide of iron with water:—

Peroxide of iron	85·6
Water	14·4
	100·00

It occurs in rocks of all kinds, being produced often by the decomposition of other ores. Water containing carbonic acid also dissolves out the carbonate of the protoxide, which, on exposure to the atmosphere, is converted into the hydrated peroxide and precipitated, carbonic acid being given off. In this manner it may be observed how rain-water, percolating through soils containing much iron, issues out of the drains full of carbonate of the

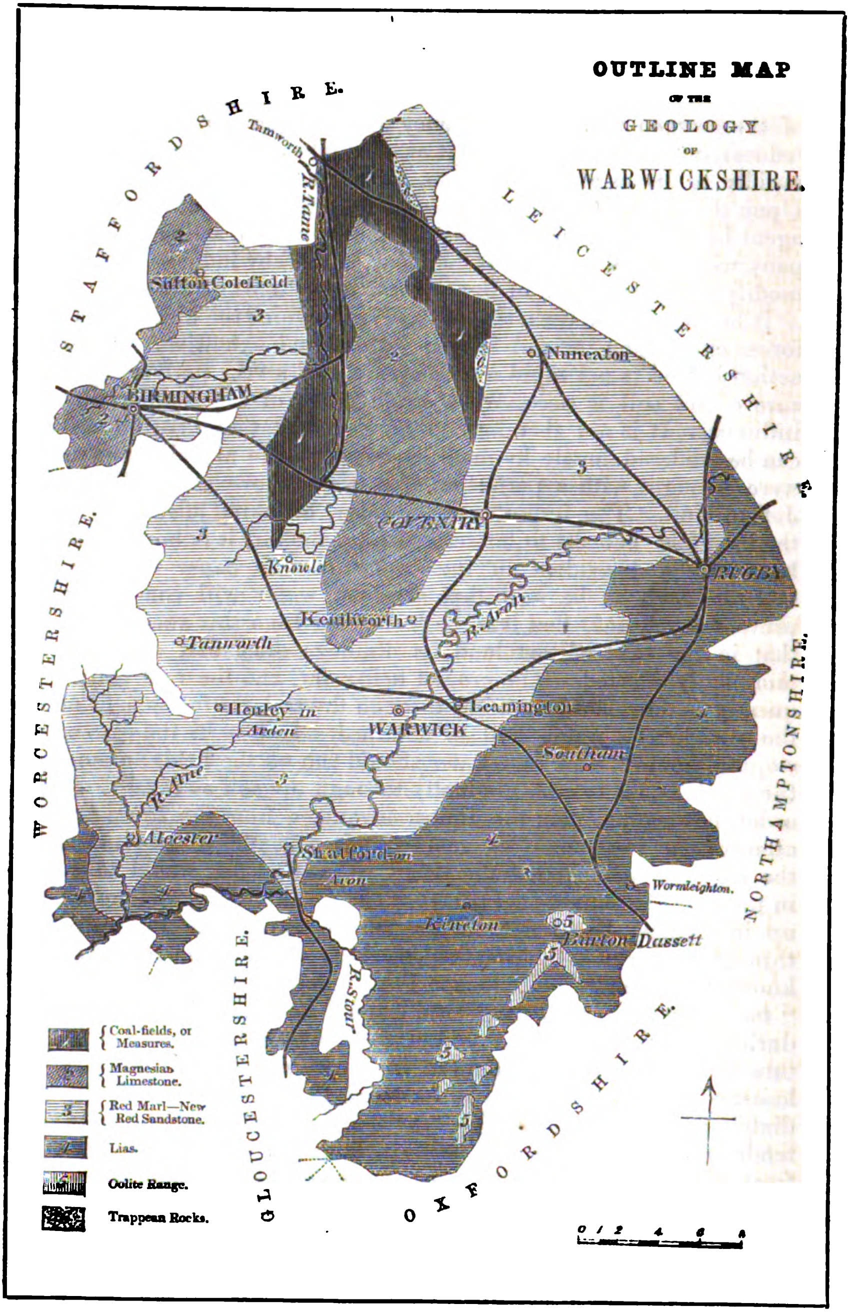
protoxide in solution; on coming into the air a brownish rusty-like scum is deposited on the bottom of the water; this is the hydrated peroxide formed by the oxygen of the atmosphere. The upper layers of beds of carbonate of iron are also occasionally found changed into this substance. Iron rust is a similar product, and both are frequently, perhaps almost always, found to contain some ammonia, which they greedily absorb.

7. *Bog Iron Ore* is also a hydrated oxide of iron, but is so frequently mixed with other ingredients that no definite composition can be assigned to it. It may contain phosphoric acid to the extent of 11 per cent., also sulphuric acid and the vegetable acids of plants. It would appear to arise often from the decay of the pyrites and other iron ores in trap rocks. As its name indicates, it is found chiefly in bogs and swampy grounds.

Many other ores of less importance occur, but the above are perhaps those which most concern the subject of this paper. Hardly any soil or rock exists, perhaps none, of which iron does not enter to some extent into the composition. It has been seen that it frequently acts as a base to silica, replacing alkalies and alkaline earths. It hardly exists naturally in the free or metallic state; but disseminated as it is so abundantly and so generally through mineral and earthy matters in the forms of its oxides and salts, it becomes a fruitful source of change and disintegration in their composition. This arises from its strong affinity for oxygen; existing in undecayed minerals, chiefly in the form of the protoxide, it is displaced from the acids to which it is united by the action of the alkalies; it then probably unites with the carbonic acid of the air in the first place, and, as has been before said, may then be dissolved out in the form of carbonate; the salts of the protoxide of iron have, however, so strong an attraction for oxygen, that on being freely exposed to the air they greedily absorb that element, and pass into the peroxide. So great is the affinity of the protoxide of iron for oxygen that it is scarcely known in its isolated condition, and its properties are to some degree uncertain; its colour, for instance, is somewhat doubtful, but is supposed to be, in the anhydrous protoxide, blue, and its salts are generally of a dark greenish or blueish tint. As the oxidation of iron does not go on unless some degree of moisture be present, it has been thought to have the property of decomposing water at the common temperature and of deriving its oxygen from that body, the hydrogen thus liberated uniting in some cases with nitrogen to form ammonia, a substance which is very frequently found present in the resulting peroxide. It has, however, been maintained by others, and apparently upon good grounds, that this ammonia has not been generated in the manner above alluded to, but has in all cases been absorbed by the peroxide from the atmosphere or from other

sources. So remarkable is the affinity of pure iron for oxygen that, when formed under certain conditions by depriving its oxide of the oxygen through the agency of hydrogen at a heat below redness, on exposure to the air it at once takes fire, returning thus rapidly to its original condition, as was remarked by Magnus. Upon the whole it may be supposed that the chief atmospheric agent by which iron will be affected is the oxygen, acting in company with moisture, and that the changes thereby induced greatly modify the constitution of the mineral ingredients of the soil.

It has been seen, then, that the influence which the atmospheric forces exert upon the soil is very various and extensive. Their action indeed is not rapid nor energetic, and a very perfect exposure of the soil is necessary to catch much of the ameliorating influence. It is not therefore to be expected that a barren soil can be rendered fertile by mere exposure to the air, although it were wrought with a perfection that would have satisfied even Jethro Tull. The importance, however, of taking advantage of the manifold benefits to be derived from the air, it is hoped, has been rendered evident in the course of this paper. It need scarcely perhaps be said that stagnant water will completely prevent any benefit that is to be looked for from this source, and that in the case of wet land its drainage must first of all be thoroughly effected. The ground being dry, and the rain consequently enabled slowly to filter through the soil, the full benefit of the atmospheric waters will be obtained. Unless in the case of sloping grounds, little rain-water should run off the fields; almost the whole ought to sink gradually through the soil as it falls. In order, however, to gain the utmost advantage from the frosts and atmospheric influences, as great a surface should be exposed to the air as possible; and the best way to effect this would seem, in the case of ground under tillage, to be, to have the soil ploughed up into ridges like potato drills, and to leave it in this shape through the winter—a practice of which the advantage is well known to gardeners. Sir Joseph Paxton, for instance, advises that "the surface of all strong land should be laid up in ridges during the winter, as the action of frost, by expanding the moisture in it, leaves it when thawed in a fine pulverized, friable, or loosened state, by which it is rendered fertile, and ready immediately after levelling in favourable weather to receive the intended crop." Many other benefits, however, than those of the frost will result. Are the oxygen—ammonia—carbonic acid—nothing? Let the agricultural mind therefore be of good cheer; the atmosphere is a force everywhere present; although his farm may be like Justice Shallow's, "barren, barren," he has at least this consolation—"*Marry, good air!*"


OUTLINE MAP
OF THE
GEOLOGY
OF
WARWICKSHIRE.
STAFFORDSHIRE.
LEICESTERSHIRE.
WORCESTERSHIRE.
NORTHAMPTONSHIRE.
GLOUCESTERSHIRE.
OXFORDSHIRE.
Tamworth
R. Tame
Sutton Coldfield
Nuneaton
BIRMINGHAM
COVENTRY
RUGBY
Knowle
Kenilworth
R. Avon
Tanworth
Henley in Arden
WARWICK
Leamington
Southam
R. Alne
Alcester
Stratford-on Avon
Wormleighton.
Kineton
Burton Dassett
R. Stour
Coal-fields, or Measures.
Magnesian Limestone.
Red Marl—New Red Sandstone.
Lias.
Oolite Range.
Trappean Rocks.
0 1 2 4 6 8

XVI.—*Farming of Warwickshire.* By Henry Evershed, Gosfield, Essex.

Prize Essay.

With a soil of more than average quality, an equable climate, and a tolerably level surface for the plough, the farming of this county derives encouragement from the large population of Birmingham and other considerable towns, rendered easy of access by numerous canals and railways which intersect its area in all directions. It is also known as the most central county of England, the town of Coventry being distant 91 miles from each of the ports of London, Bristol, Hull, and Liverpool.

The following is the *acreage* of the Hundreds:—

	Acres.	Population in 1841.
Knightlow	182,350	100,250
Kineton	119,690	24,043
Barlichway	100,310	28,961
Hemlingford	141,440	55,764
	543,790	209,018

The parish returns, however, give the higher aggregate acreage of 567,930. The following is a Table of the increase in population since 1801, including that of towns, which in the above estimate is omitted:—

Years.	Population.	Increase per Cent.
1801	108,190	
1811	228,735	10
1821	274,392	20
1831	336,988	23
1841	402,121	19
1851	475,013	18

The average rental of land in this county is 1*l.* 5*s.* 6*d.* per acre, the average of England being 19*s.* 2*d.*

Our description will comprise four agricultural divisions: first, the heavy clays lying south of a line drawn from a point a little below Dunchurch, to a point three miles south of Stratford, and running through Long Itchington and Friz Hill; secondly, the rich loams on the banks of the Avon; thirdly, the clays and red marls at the south-western corner, beginning between Tanworth and Henley, and meeting the loams of the Avon at Snitterfield; and lastly, the whole of the remaining portion of the county, consisting of various loams, sands, gravels, and clays.*

* These belong to the new red sandstone, and, towards the south of the county, to the lias formation. The Gravel forms an extensive deposit in the north-central district, consisting chiefly of small boulders and sea-worn pebbles of ancient rocks traceable to the parent beds in Yorkshire, Cumberland, and Scotland, and commonly

The Warwickshire *Coal-Field* stretches from the east of Tamworth, along the borders of Leicestershire to Nuneaton, and thence on each side of the road to Coventry, to within two miles of the town. The coal-measures preserve a breadth of about three miles. As the beds dip rapidly, and are mantled round by the superior strata of sandstone and marl, the agricultural character of the district differs little from that of the surrounding country; and there is little of that cold, poor clay-land which often prevails near the coal-fields elsewhere. Large masses of compact greenstone are found in this district, and are now transported to every part of the county for the mending of roads. It is called, from the spot where it is dug, Hartshill-stone.

The *New Red Sandstone* spreads over the greater part of Warwickshire. It occupies the whole of the central and northern portion, with the exception of the coal-fields. On the south it meets the lias at a line drawn across the county from a point a mile south of Dunchurch, through Long Itchington, and thence to Friz Hill, and into Gloucestershire, a little to the south of Stratford-on-Avon. We have not the means of pointing out with exactness the beds of marl, sandstone, and conglomerate of which this formation consists. The red clays are found at the south-west corner around Henley and Alcester. At Kenilworth, and thence to Coventry, the soil rests upon a sandstone rock,

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known as the "Northern drift." Quartz pebbles especially abound in it; granite, gneiss, sienite, porphyry, slate, mica schist, trap, and almost every other variety of the primary rocks may be collected.

The course of the Lias may be traced from the neighbourhood of Edge Hill (where its upper beds of black shale, with bands of blue and grey limestone, occupy the same relative position as in Gloucestershire and Somerset, forming the top stratum of the hills, overlying the marlstone), towards Harbury, where its lower beds are intersected by a long deep cutting of the Great Western Railroad, being composed of blue clay and shale, traversed by irregular beds of limestone. The marlstone, between the upper and lower beds of the lias, is a hard micaceous sandstone, 20 feet thick, and is largely developed at Edge Hill. The strata immediately below it consist of clay and ironstone, rich in iron ore, especially at Chipping Campden. Some fine sections of the lower lias may be seen at Mr. R. Greaves' extensive quarries at Stockton. It traverses the county by Henley in Arden, Stratford, Kineton, Southam, and Rugby, whence it may be traced into Leicestershire. The total thickness of the Lias in the midland counties is 500 feet.

The new red sandstone, spreading out from Gloucestershire and following the lias in its north-east course, occupies a considerable area in Warwickshire. Its *upper* red marls may be observed near Alcester and Stratford. It is the great depository of salt and gypsum, furnishing the mineral waters of Cheltenham and Leamington. Underneath this, capping the Alne Hills and stretching towards Henley in Arden and Preston Bagot, is the grey and white sandstone, called the Keuper sandstone. Near Knowle there is a kind of basin of red marl, with a small outlier of lias in the centre; the Keuper striking thence by Lapworth and Rowington to Shrewley, where the following section may be seen in the cutting of the Great Western Railway, viz., red marl, 40 feet; sandstone and green marl, 20 feet; red marl, 10 feet: total 70 feet. Between this and the Warwick sandstone there is a great thickness of red marl, well displayed at Hatton Hill. This is succeeded by the soft white sandstone of Warwick, and the still lower red or bunter sandstone of Kenilworth and Coventry.—C. W. Hoskyns.

favouring the growth of oak and other timber. Generally throughout the tract the surface consists of a soil more or less heavy, with an abundance of rolled gravel-stones, here and there giving way to sand, as at Sutton Coldfield, Meriden, and Cubbington. Marl is dug almost everywhere.

The lias, shale, limestone, and clay occupy that portion of the county south of the line before pointed out; and some outliers of these beds also cross the Avon, and are thrown up between Stratford and Alcester.

There is a detached range of hills belonging to the inferior oolite on the borders of Northamptonshire and Oxfordshire; among these the bold escarpment of Edge Hill commands a view of the famous battle-field below, and of an extensive tract of country.

Allowing for the differences of good and bad farming, which in Warwickshire are unusually great, the systems pursued on the lighter soils are much the same in every locality. We shall endeavour to give a general outline of the varieties of routine pursued, defining, as nearly as we can, the practices of the different districts.

The Avon District is a strip of loamy soil running across the county from Stratford to Rugby, following the course of the Avon, and extending three or four miles on either side of its banks; the strongest loam, and probably the most productive land in the county, is a level tract between Stratford and Warwick, which forms the northern limit of the Vale of Evesham. Mr. Murray pronounces the farming here the best in the county; and perhaps the distinction still exists, but not to the discredit of the farming skill to be found in other parts of it.

The farms here are large, averaging 300 acres; there are a few of small size, and some of 500 or 600 acres; rents are from 25*s.* to 30*s.* for the second-rate land, and 35*s.* or 40*s.* for the best; rates, 2*s.* 6*d.* to 3*s.* 6*d.*; tithe rent-charge, 3*s.* to 5*s.*, sometimes redeemed. The course of cropping is 1st, turnips; 2nd, barley; 3rd, seeds, or peas, or beans; 4th, wheat; 5th, beans; and on the strong land, 6th, wheat. Vetches for fodder are largely grown. The plan of taking intermediate crops of them is on the decrease; but occasionally turnips are taken after early vetches, and also after the most forward crop of wheat or peas. Neither rye nor trifolium is grown. The wheat-stubbles are forked in autumn, ploughed 6 to 8 inches deep, ploughed again in spring, and once or twice more afterwards, the dung being turned in the last time, and the swedes drilled on the flat with a top-dressing of guano and superphosphate. In a few instances, the improved practice of ploughing in the dung in autumn has commenced,

followed by a lighter and more compendious spring tillage. The success of this method has induced others to adopt it.

The wheat is drilled in October and November, beginning with 2 bushels, ending with 2½ bushels per acre. Only a small quantity of white wheat is grown, perhaps not one acre to twenty of red; there is some Talavera and a little Coln, but the latter requires a strong clay soil, and on the loams produces very thin light grains. Varieties have much increased from the natural desire to improve so important a cereal; the favourite sorts, however, are Burrels, American Red, and Red Lammas—the latter is decreasing. The clover ley is seldom dunged for wheat; the young plant depends for support on the dressing left by the sheep pastured on it: in spring, guano, nitrate of soda, or some other manure is given if the plant require it, and the farmer can afford it. Beans (the White-eye and Water-bean for spring, and sometimes winter beans) are dibbled or drilled in autumn or in February; the latter season is preferred; and when following the wheat crop, the stubble is forked and the land ploughed once before winter, and again for sowing: a point is made of dunging for beans. Of barley many sorts are grown, but chiefly Chevalier. It is drilled after once ploughing, as the turnips are fed off, up to the beginning of May. About 12 lbs. of clover and a mixture of other seeds is sown in the barley; Italian rye-grass or Pacey's is sown in the place of common rye-grass. But the former, though probably preferable, seems to be declining in use; a prejudice has been raised against it, partly from the quantity of couch-seed sold with it, partly from an idea that it is liable to grow stalky in spring. The first of these evils of course is avoidable, the latter may be remedied by early pasturing in spring, and keeping down the hard inedible stalks. The plants will then become leafy, and an evil, not easy of after remedy, will be prevented. In addition to that which is cut for fodder, a portion of the seeds, regulated by the quantity of pasturage on the farm, is cut for hay, and the greater part depastured with sheep and cattle. A coat of 10 or 12 tons of dung laid on the seeds in autumn is left exposed to the weather through the winter, and, notwithstanding, produces an effect on the vegetation in spring which warrants the application of the practice. This is one more instance of the scientific and we may say the common-sense view of top-dressing with dung being falsified by the practical results.*

* Not so. Science and common sense are agreed that top-dressings are only precarious at the time of year when EVAPORATION is on the increase, or at its height. It declines in the autumn, and almost ceases during the winter months: at such time the application of dung on the surface, both as a protector from frost to the

In the district under description few pigs or oxen are fattened; the straw is trodden into dung by cows, horses, and sheep. Dairying is pursued on a small scale, and although cows are kept on most of the farms, it is not often there are more than 10 or 12 on each. It must be remembered that in this part of the county there is little pasture-land; the grass-land is chiefly on the banks of the Avon and its tributaries, and these meadows are of course always mown. Cows are pastured on the seeds, and, strange as it may seem to farmers who cut their seeds for hay, some of the best cheese in the kingdom (taking price as the criterion) used to be made on a farm near Warwick, which is without pasture-land. Cheese has of late given way to butter-making; and cheese farmers are often stigmatized as very bad ones, and cheese-making as the great enemy of Warwickshire landlords. A small quantity of cream-cheese is made on some of the farms, and the neighbourhood of Leamington is particularly noted for it. A good many calves are reared; they are procured from the Bucks markets and raised by hand; they are fed on milk and linseed, and as they become strong, are allowed to run out in the paddocks and are fed on bran; afterwards they are kept on the meadows, seeds, turnips, and straw, and are sold at two years old in calf to dealers, who take them to the county whence they came. Sheep are the main stay, except on farms where the number of cows makes it necessary to banish other stock during the summer months. The breeds kept throughout the county are the long-wooled, generally crossed with the Southdown. In Mr. Murray's time, what he calls the "ancient Warwickshire sheep," a large polled sort, was most in vogue; "the average size when hogs and fat is 23 lbs. per quarter. A dispute arose between Mr. Bakewell and Mr. Palfrey, a breeder of the Warwickshire sort, as to the comparative merits of these and the Leicesters, which ended in a cross being proved the best." The fleeces of the old Warwickshire used to average 9 lbs. each, of the mixed, 6 lbs. There are some farmers in the neighbourhood of Warwick who still keep this large uncouth breed, which was formerly spread over Warwickshire, Northamptonshire, and Lincolnshire. Bakewell's improved Leicesters were produced by making selections from this stock and breeding from the progeny; and in general they have been crossed so as to lose their original characteristics, or replaced by Cotswolds, Leicesters, or Shropshire sheep. The plan of using cross-bred rams, so pertinaciously adhered to by some men, whose maxim is to use what costs least, is giving way; and farmers now prefer rams of the above breeds, or a pure

young plant, *and* as an enrichment of the moisture falling on and filtering through it into the soil below, is in perfect accordance with the best procedure which science could suggest, had not practice already established it.—C. W. H.

Sussex down, and use them as their flock may require frame, quality, or wool. The wool from a well-managed flock averages 4½ fleeces to the tod. Ewes are sheared four times, and then fattened; and the number is kept up by drafting from the maiden flock. Contrary to the notions of many breeders, the ewes are kept on swedes previous to lambing, and this, when plenty of dry food is given, is not considered injurious. The stiffer loam above Warwick will not bear the treading of the flock except in dry weather, and this forms an excuse for the old-fashioned system of bare fallow for wheat, which on the soil now under description is unwarrantable. One-half only of the turnip crop is fed off, and the ewes are taken every night into the yards, where they have the picking of the straw, and some hay where it can be spared. On lighter land the ewes are kept entirely in the fold, and have their cribs filled with pea, bean, or other straw, and rough hay. Some provide lumps of salt in the troughs for them to lick. In this way they are kept until the seeds are ready in spring; but the flock is at this critical time often somewhat straitened for food before they can get on the seeds. With a few turnips thrown to them at first, here they remain through the summer until the meadows are ready. The vetch crop is consumed by the tegs.

Murray says, "In most parts of the county they plough from five to eight inches deep, and use from four to five horses in a plough, one yoked before another." The depth of ploughing remains the same; it is quite the exception to go deeper than eight inches. There are some of the old-fashioned curved ridges, gathered very high even on the loams and gravels; however these may have been formed, there is a horror of reducing them, for fear of laying bare the subsoil at the centre of the crowns. We may perhaps strike off one horse from the number named by Murray; but we must admit that much of the lighter land is ploughed with three at length, which might be done with two abreast. To advocate the latter plan in all instances is, however, absurd; for although we have seen a plough with two horses slicing the soapy clays of Sussex with apparent ease, we must record that on a tenacious loam the draught is so much heavier as to completely defeat the practice.

Reaping in this county is more common than bagging or mowing; but as most of the harvesting is done by Irish labourers, it is difficult to alter the practice. *Hooding* or *capping* the sheaves is common in some parts: it is not practised in the neighbourhood of Warwick, yet nowhere is grain brought to market in better condition.

Horses in this county are generally of a good sort—neat, short-legged, and active. Derbyshire horses are preferred to Suffolk or

Cleveland. One-horse carts and two-horse ploughs go together: the common practice of this county exhibits but a small proportion of either. In carrying out dung, some use four or five horses to a cart, and this on land by no means hilly. An instrument which will be a novelty to some of our readers is the *double-plough*, which, not content with figuring on the signboards of some of the country inns, is still made use of even by some intelligent farmers. The beam is 9 feet long, the handles 5 feet, and the beam is either crooked to the right or a cross-piece is mortised-in to carry a second mould-board; the front one is the smallest, and following close behind is the larger one, 4 feet long. Four, five, or even six horses are harnessed to it, and two furrows turned at once. Some look with contempt on the machine; but specimens may still be seen. It had its origin on the clays, and is still largely used to stir the fallows, for which purpose it is here thought invaluable. In good weather it will plough nearly 2½ acres a day.

The clays south of the Avon tract vary from a rich old pasture soil to a poor lias clay, or a rubbly limestone. The best grazing-land is on the borders of Northamptonshire and Oxfordshire—at Grandborough, and from Wormleighton to Farnborough, Burton Dassett, and Radway. At Wormleighton some of the poorer pasture has been pared and burnt and ploughed up; the rich old turf remains untouched. At Burton Dassett one may follow the foot-path for four miles on the road to Kineton and only cross two ploughed fields, and the cattle are seen grazing with equal relish in the flats and on the bare mounds which here and there break the level surface. Herefords and shorthorns are preferred by the graziers; but no great attention is paid by them to the breeds which they purchase. The best land bears one ox per acre, or one ox and three sheep on two acres. The last reporter of Warwickshire farming remarks on the lamentable way in which some of the pastures were laid down, and on the unevenness of the surface and the wide spaces between the ridges, which remain soaked instead of conducting away the water. Draining and levelling have in a great measure checked these evils, and the rushes and sour grass which marked the wet furrows have in most cases disappeared; but some of the land that has been subsequently laid down is in the worst possible plight. It was cropped by the worst farmers until it bore nothing, and then not *laid* down but allowed to *run* to grass, or rather to *couch*. Nothing but paring and burning, a good summer fallow and manuring, can cure it. Clay-land, even when productive, is, from the capital and energy required in its cultivation, more liable to be abused than any other.

Pasture-land on the southern side of the county is in the proportion of about one-third of the whole; towards Kineton it

increases to one-half—the farms averaging about 200 acres. It is remarkable that some of the grass-land in this district is peculiarly liable to scour ("fret") the young cattle. This is more especially the case where the limestone-rock is covered 15 or 20 feet with clay, and as the rock becomes shallower the evil decreases. It occurs on a strip running by Southam and Kineton, and is so injurious in its effects, that some of the farmers cannot even keep a cow on their farms, and are obliged to purchase milk for home consumption; yet the same land will fatten freely horses and sheep. Those who persevere with grazing under these disadvantages are compelled to see the thriving of their cattle checked by fretting, which is sure to attack them, although not at any particular period.* Black cattle have been observed to turn on this land to a dun colour. In the absence of any known remedy, either applied to the land or to the animals themselves, there is no doubt that much of the grass land should be brought under arable cultivation.†

The great drawback in the district is the small amount of root-crops grown, even on the soils suited to them. Those who grow none at all have three or four times more sheep in summer on their pastures than they can keep in winter, and they are often obliged to put out part of their flock to those who grow roots.

Lime is much used on the fallows, and, mixed with road-scrapings and soil from ditches and banks, is applied to the pastures. A few pigs are fattened. In former times, when several labourers were boarded in the farm-houses, seven or eight hogs would be consumed by the household; but now this custom has disappeared, and fattening seems to have fallen off. It is preferred to drill all crops on a stale furrow—the staler the better; oats are but little grown. The average wheat-crop is stated at eight bags (three bushels each) per acre.

The Red Marls.—The south-western corner of the county, between Henley, Alcester, Bidford, and Snitterfield, consists of a reddish soil, which we may describe as a loam on marl, a loam on clay, and a loam on gravel—the latter bearing turnips which may be fed off, the former requiring draining. The farms vary

* This is the general remark, but at Chadshunt, on a farm of 1300 acres, cattle do well up to July; they are then removed to other pastures, and may be turned on again without injury in September. Forty-five acres on this farm have been broken up and drained; first-rate crops of wheat and beans are the result.

† This is a matter of complaint well known, and fully meriting investigation both by the chemist and the botanist; and, indeed, by the geologist, inasmuch as the belt of land upon which it occurs seems to lie at the junction of the lower lias bed and the upper red marl of the red sandstone. The old-fashioned precaution, upon such morbific pastures, of turning in a flock of geese for two or three days before the cattle are admitted would, if really corrective of the evil, as it is said to be, seem to point to some botanical peculiarity in the herbage, which might, with care, be discovered.—C. W. H.

from 150 to 200 acres, and many are still smaller. The fields are in general small and crowded with timber. The grass land is chiefly on the banks of the Arrow and the Alne, and a proportion of three-fifths is arable. The course of cropping is, 1st, fallow; 2nd, wheat; 3rd, clover and rye-grass (often for two years); 4th, wheat; 5th, beans, and sometimes 6th, wheat: Or, 1st, fallow; 2nd, beans; 3rd, wheat; 4th, seeds; 5th, wheat. Few peas or oats are grown. Root crops are strangely neglected; and draining as little thought of as if pipes were not invented, or stones were not to be had for the picking. In fact, this district, with all its advantages of soil and situation, and with Birmingham market close at hand, seems (with the exception perhaps of Bidford) to have been overlooked in the general advance, and is still pursuing the practices of 100 years ago. Twenty-four to twenty-seven bushels of wheat, and the same quantity of beans, per acre, are the average crops. Judging from what is done in several instances which could be pointed out, the average produce of many of the farms might, with proper management, be increased 50 per cent.

The best farmers plough for beans before Christmas, and sow the white-eye or water-bean in February; but many do not touch their stubbles until spring. Drilling is by no means common, and at least one-half of the farmers sow and plough-in their wheat. A good plan, only adopted by the better farmers, is to plough-in dung in autumn, scuffle in spring, and drill barley on a stale furrow. By this method a much better plant of clover may be expected than by sowing it in wheat, as is commonly done.

Leicester sheep, often crossed with the Shropshire down, are common, and on the gravelly soils, where turnips are grown, are kept in the fold through the winter, or they are kept in yards and run out into the meadows, and get a few turnips thrown abroad, and straw given them in sheep-racks. In summer they are grazed on the pastures without corn, and the store sheep run on the stubble in autumn. In some cases, by draining, this land has been made to bear treading; and a few farmers are persevering enough to grow swedes and mangel on the heavy land, and cart them off.

Cows of the Short-horned, Hereford, or, more frequently, of a cross-breed, are kept for cheese-making and dairying. A first-rate dairy will produce, on an average, 9 or 10 lbs. of butter per cow for each week during the summer months, or 500 lbs. of cheese per cow per annum. This is under higher feeding than common, though some men boast of producing that amount without corn: 300 lbs. of cheese per cow is an average produce. Each cow gives about 1 lb. per week of "second butter," fetching *2d.* per

lb. less than the best. The small farmers save their own bulls, and as they never expend anything for a superior animal, the breed deteriorates rather than improves: pure bred stock is not common. Much of the land lies in high ridges, which, after furrow drainage, require to be reduced with care, as there is little extra depth of soil at the crown.* The Birmingham and Stratford Canal passing through this district supplies the farmers, who avail themselves of it, with manure. Artificials are little used; guano is sometimes applied to the corn in spring, but it is quite an exceptional case. As few pigs are kept, little corn given to cows, and but few oxen fattened, the quantity of manure applied to the land is very meagre.

The Northern District consists of that part of Warwickshire lying north of the Avon and of the tract we have just described. The soils vary from a gravelly loam, of various degrees of fertility, to the sands of Meriden Heath and Sutton; there is also a small portion of heavier land, particularly in the neighbourhood of Tanworth and the coal measures. There is a pasture tract on the eastern side, on the borders of Leicestershire, but, generally speaking, the land is in arable culture, and the greater portion of the grass land is on the banks of the numerous streams. In the neighbourhood of Birmingham farming merges into market-gardening. Rents vary from 2*l.* for the strong to 1*l.* for the light land, and, near the town, 3*l.* to 4*l.* Under the head of stock we may mention dairies of from 10 to 15 cows; sheep in numbers, which are yearly augmented by the draining of the land; and oxen and pigs which are fattened, though not in large numbers, by the larger and better farmers. The stock is maintained through the summer by depasturing nearly the whole of the seeds, which, in accordance with the custom of this county, are heavily manured

* Whenever a transverse sectional view can be got across one of these old high-ridged fields, the appearance below the plough-line, on the tops of the ridges, is as completely that of *subsoil* as though it had *never* been stirred. It is difficult to account for this, as the ridge itself *implies* the commencement of the tillage *upon the level;* and the difference of the soil and subsoil (in the district spoken of) is too striking to leave it easily credible that the once-cultivated soil could ever return to its subsoil texture and appearance. A field of this description was drained (down the furrows) in the autumn of 1844, and the ridges cast; it was cross-ploughed, scuffled, rolled and harrowed, in the spring, and, when quite level, sown with barley and clover-seeds, with a top-dressing of guano. The opinion expressed by one or two neighbouring farmers was that the crop would be bad on the site of the old ridges. *The reverse was the case* to a degree very strikingly perceptible during the whole period of growth. The difference was equally observable in the clover crop the following year. The explanation may perhaps be this,—that deeply as the soil had been gathered into the old furrows, it furnished less mineral food to meet the demand of a manure rich in ammonia than that which had been newly restored to cultivation on the ridges. On another field, levelled in like manner, and laid down with permanent grass-seeds, the opposite effect (conformably with the caution in the text) has continued to exist, the pasture being best on the sites of the old furrow.—C. W. H.

in autumn. The seeds are a mixture of clover and Italian or Pacey's rye-grass. The following is a favourite mixture, sown for two years' pasture:—8 or 10 lbs. cow-grass, 2 lbs. Alsike clover, 2 lbs. trefoil, 1 lb. rib-grass, 1 peck Pacey's rye-grass, 1 gallon Timothy grass. The bane of Warwickshire farmers is the failure of the clover plant, from its too frequent repetition: it looks well and flourishing after harvest, and in the winter months gradually disappears, until sometimes not a single plant is to be seen. This "clover sickness" seriously affects the prospects of succeeding crops, since it not only robs the land of the clover root, but lessens the amount of stock which can be pastured. The remedy lies in less frequent sowing—not oftener than once in eight years. In the mixture given above, cow-grass is used as a relief from clover; but probably a complete rest from the clover family is the only way to insure success. The bone-manure of Messrs. Proctor and Ryland, of Birmingham, is applied on clover with great success: the cattle greedily feed upon the land so manured, leaving untouched any part of the field not dressed. Its effects are said to be greater on heavy land than on light loam. This manure, which is prepared for turnips and other crops, has obtained an extensive sale in this and surrounding counties.

In Mr. Murray's time, sowing turnips broadcast was the general practice, and we find him combating the arguments that drilled turnips grow too large, are spongy, and have not that sweet flavour the others have. Drilling was, however, gaining ground. He says, "The leaving the drills of too great elevation above the level of the field is a mistaken idea; it is not requisite, and when the turnips are ready for folding with sheep they should be nearly level:" this is now the case; and by the time the hoeing is done the ridges can scarcely be distinguished. A plan, which is recommended on heavy clays, is to dung and ridge in autumn, cultivate between the rows in spring, destroy with the hoe any weeds which arise on the ridge, and drill on the stale furrow. Mowing wheat, instead of reaping, is greatly on the increase, and light iron ploughs are rapidly taking the place of the old-fashioned implements; double-ploughs are, however, frequently used in the fallows, even by many of the best farmers. The buildings are perhaps better, because not so numerous as we have remarked them elsewhere.

Sheep, either Leicesters or Cotswolds, or crosses with the Shropshire or Sussex downs, are bred and fattened at two years old. The flock runs, through the summer, on the seeds and grass, and the following winter the tegs are fattened. The ewes are drafted off fat after their third lamb. On farms where there is no dairy, oxen are fattened in the yards on cake at 3 years old; there are

a few excellent short-horned cattle bred; they are grazed on seeds through the summer, and run in the yards from November to May. The Tamworth breed of hogs is common in this as in other parts of Warwickshire; the number fattened is not very large. One plan of feeding them deserves notice, because it accords with a favourite notion of Arthur Young: it is, to give them sour food. Swedes are boiled and mixed with one-third of meal, a couple of cisterns are filled, with a week's allowance in each, and the food is used a week old, and in a sour state. The meal is increased as the animals fatten.

A plan which an excellent farmer has adopted for economising liquid manure, and which has the advantage of being cheaper than the tank and water-cart system, is to dig a hole outside of every yard, fill it with all sorts of rubbish, and make it the receptacle of the drainage, carting away the stuff when necessary. The escape appeared very trifling.

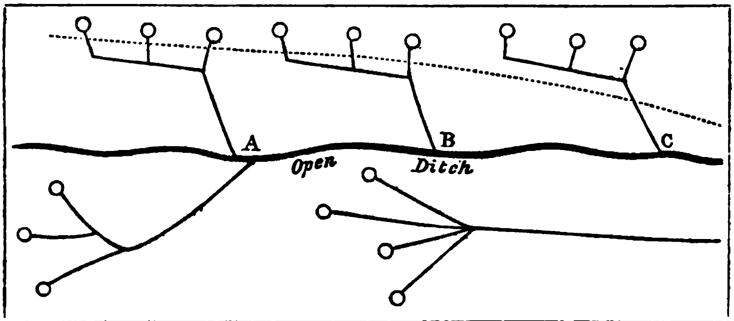
In the neighbourhood of Birmingham a great deal of the land is under spade culture, and large quantities of vegetables are grown for the town. Potatoes are planted on the clover ley, first ploughing flat, then trenching 18 inches deep, and placing the dung and the turf on the top of the bottom spit. Then follows wheat and afterwards potatoes and turnips.

Draining and Irrigation.—Some writers have awarded to Joseph Elkington of Princethorpe, in this county, the merit of being the originator of under drainage. In Sinclair's Code of Agriculture we read as follows:—

"In the year 1764, Elkington began to drain some fields on his farm of Princethorpe, which were so extremely wet, as to rot several hundreds of his sheep. He had dug a trench for that purpose, about four or five feet deep, which did not, however, reach the *principal body of subjacent water*. It is said that, while he was deliberating what was to be done, a man was passing with an iron crow-bar. Being desirous to know what sort of strata lay under his drain, he forced the bar down about four feet below the bottom of the trench. On pulling it out, water burst up through the hole, and ran down the drain. This led him to the knowledge, that wetness may often be produced by water confined farther below the surface than the usual depth of drains. For his success in acting on the hint, by boring, as well as other modes of draining, and readiness to communicate his principles to the Board of Agriculture, a thousand pounds was voted to him by Parliament."

We give a plan of a piece of ground drained by Elkington, which forms a portion of a narrow strip of land of 35 acres, formerly filled with water from the hills which rise on either side, and now converted from a peat-bog into productive water-meadows. The dotted line running under the hill represents Elkington's drain, pierced at intervals of 9 feet with auger holes; from these the water rose into a covered sandstone drain. By this simple and inexpensive process the land would have been

effectually drained, had not an unforeseen obstruction arisen to thwart the whole work. It was found that in the course of a few



years a yellow, ochrey matter, common in peat bogs, completely choked the drain, and prevented the auger holes from working.*

By this unexpected circumstance the plan of boring, often successfully practised by him, was for once defeated. The evil is now remedied in the new drains we are about to describe by opening into them holes at intervals of 20 yards, introducing a No. 3 wire of proper length, and working through a brush of wire and whalebone; an operation which has been necessary four or five times in the last thirty years. On the failure of the old drain the present occupier dug the drains which are marked in the plan, and which run into the main ditch at A, B, and C. The peat is 5 or 6 feet deep: below is a subsoil of gravel and sand, and under that a "bind," 1 foot in thickness, consisting of a tough impervious agglomeration of sand, clay, and gravel. To draw off the water it is necessary to pierce this bind, and this was done by sinking shafts of 14 or 15 feet in depth. They were sunk at spots which, according to the notion of the drainer, would best tap the springs; on one side of the ditch they occur with some regularity under the hill, on the other they are scattered over the meadow. These shafts were dug 9 feet in diameter, to allow of two men working in them at once, a necessity caused by the rapid flow of water. Each shaft was filled with stones to a level of 1 foot above the drain, and through these stones the water rises and pours off into the main outfall, leaving the land perfectly drained. The drains are 4 feet deep at the outfall, and increase to about 8 feet at the shafts. The 17-acre meadow which we have described forms the upper portion of a 35-acre piece; the lower part is drained more expen-

* These auger-holes worked as well as ever when the land was redrained, after a lapse of fifty years.

sively and less effectually by a drain cut under the hills parallel with them at about 9 feet deep.*

Warwickshire has more than an average of wet, or clay lands, which offer but small encouragement to the cultivator until they are drained; and we may say of this, as of other counties, that the work proceeds rapidly, but much remains to be done. Fields laid out in 8-feet ridges have the drains placed in every third furrow; there has been a general disposition of late to drain deeper, and the instances are common of pipes laid at 30 inches being taken up and replaced a foot deeper.

Deep ditches, cut at no small cost or labour, and narrow ridges, have disappeared, superseded by the draining-pipe; crooked hedge-rows, and high banks, have been replaced by neat fences of quickset. We saw some admirable hedges of quickset on a gravel farm, where everybody declared they could not be produced; a trench, 30 inches deep by 30 inches wide, was dug out, and filled with mould, with the addition of a small quantity of manure, and the plants were thus forced into rapid growth.

Mr. Murray considered irrigation neglected in this county; and we are sorry to say it is almost equally so at the present day. Authorities tell us that streams, which produce water-cresses and good trout, may be looked upon as adapted for irrigation, the water proving in general congenial to the growth of the grasses. In Warwickshire, with its numberless streams and rills, the water teems with these evidences of its available character; it is nevertheless seldom made use of. The practice seems even less appreciated than at a former age; the Stour, at its junction with the Avon, was evidently once employed

* It is almost unnecessary to say that this mode of drainage (of which a detailed description like that in the text may perhaps be not inappropriately retained in a report of the county in which Elkington was born, and practised his system) is properly superseded by the modern practice of deep parallel drains. Except to meet the very rare case of insuperable difficulty of outfall, holes sunk below the bottom of a 4-foot drain to *bring up* water from greater depths are useless. The specific action of drains of proper depth and interval upon the adjacent soil is obviously the same, let the *source* of the fluid be what it may. Probably in no art to which they have ever been applied have the laws of hydrostatics been more outraged than in that of land drainage. Their extreme simplicity (compared with those which are concerned with elastic, imponderable, or invisible bodies) has often been the very stumbling-block of half-informed minds, which look for and exact a certain amount of the mysterious as an element inseparable from, and necessary to the dignity of, science. To such persons—and unfortunately 'professed' drainers of local celebrity sometimes belong to the class—simplicity ("the test of truth") is distasteful, and demonstration useless. Thus in some very drain-needing parts of North Warwickshire it is a common belief that water "*draws better*" down a curved drain than a straight one; and, in one instance, it was not until after reiterated arguments, and, after all, not upon sincere conviction, that a man *superintending* the drainage of a rather level field, could be persuaded that a "sharper" outfall could be obtained down *one* side of a square than by going round the three other sides, because there was a slight depression of *the surface* in the latter direction.—C. W. H.

to water the adjoining meadows; an embankment, formed with great ingenuity and judgment, and which must have directed the water over about 70 acres of land, still remains.*

In the vale of the Tame near Birmingham, something more has been done. The brook Aston, which runs round the north and west side of Birmingham, and receives the sewage of that part of the town, was directed from its course many years ago, near its confluence with the Tame, and employed to 'float' 60 acres of meadow; in the year 1820, a proprietor on the opposite side of the Tame, conducted the water under the river by means of a wooden trunk, which he constructed at an expense of 900*l*., and irrigated an additional 60 acres of land, paying 500*l*. for the right to use the water. By this spirited undertaking a particularly worthless soil of clean gravel, producing only short wiry grass, scarcely worth the mowing, is made to yield most abundant crops of grass. The meadows are grazed up to the middle or end of June, then the water turned on for 7 or 10 days, and the grass mown—which in a growing time will be in 7 weeks from the time of removing the cattle. Then comes a great exercise of patience in getting the hay, which, to avoid a burnt rick, must be made and re-made, long after the period when ordinary grass would be fit to carry. The crop averages two tons per acre, and, though rather coarse, is, with a little 'sweating' of the rick, excellent in quality. If the hay is got off before the aftermath rises, the meadow is again floated for 7 days, and in 8 weeks the second crop, of about one ton per acre, is cut, and the meadow grazed during the autumn months; then floated, and again in spring.

The sewage of the south side of Birmingham goes into the Rae

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* The neglect, or rather *abandonment*, of irrigation over the greater part of Warwickshire is easily explained, and by the mere mention of a circumstance that ought to have received prime notice in any physical description of the county, as it would do at the first sight of any good map of it. Occupying the most central position in the kingdom, it forms, on the north-western side, a plateau of great elevation, the district around Birmingham being in fact known as the "watershed of England." Throughout the whole of that extensive portion of the county, reaching to within three miles of Warwick, innumerable petty streams take their *origin*; diverging in every direction towards brooks tributary to rivers that flow into opposite seas. An instance, illustrative of this, occurred in 1851, when the mere alteration of the outlet of a field which was re-drained for greater depth, sent the water on its course for the Trent and the Humber, which had previously found its way by the Avon and Severn, into the Bristol Channel! Irrigation is only valuable in proportion to the fertilizing matters, mineral or otherwise, which the water has met with and dissolved in its *previous* course through other soils. The petty streams given birth to in a district of such altitude and character have not yet commenced the imbibing career that is to make them vehicles of enrichment to lower-lying pastures. The vestiges of deserted and bygone attempts at irrigation (not uncommon in the neighbourhood) convey two stories to the eye—one in their construction, another in their abandonment. The latter is the true one.—C. W. H.

and flows afterwards into the Tame; and it is said that the effect of the rich fertilizers which are washed down the stream, is felt for a distance of 15 miles. The water is employed in many other instances, but there is by no means a systematic plan of irrigation; still the value of town sewage is sufficiently evident, though it is used most wastefully. The poor gravels are, however, likely to be robbed of their liquid treasures in the event of the success of a scheme now organized for deodorizing the whole of the sewage matter and preparing it for sale; a culvert has been formed in order to conduct it to a spot out of the town for that purpose.

Timber and coppice, still abundant, were formerly much more so; the forest of Arden extended through the middle of the county, and to describe how thick the timber stood, it was said that a squirrel might leap from tree to tree nearly the whole length of the county. The finest oak woods are on the estate of Lord Leigh, but oak is abundant throughout the whole of the district called the Woodland, north of the Avon; the elm is, however, plentiful in most parts, and particularly in Camden's Feldon, or "Champian" country south of the Avon. Their noble growth marks the fertility of the soil; scarcely any stunted trees being visible in this district. On descending Frizhill above Wellesbourn, Hastings, we see nothing but elm on the loams and oak on the clay ridge above, indicating the distinctions of soil. The elm, however, grows freely on the clays at Kineton and Southam. Quite a feature in the county, is the avenue on the highroad from Dunchurch to Knightlow Cross; it stretches along 6 miles of level country, overarching the road the whole distance. Between each row of trees and the hedge is a wide strip of turf, forming a beautiful background, adding much to the effect. There are three miles of fir trees, many of them of 7 or 8 feet circumference; the rest are elm.

A decided change has taken place for the better in farmhouses. An inferior house—whatever may be the merits of the farm—is a serious obstacle to the letting to good tenants. The wisest landowners, aware of this, take care to build substantial and comfortable residences; better cottages follow in the wake of other improvements, but there are many remaining which are mere hovels, where a single bedroom has to suffice for a whole family. The cottages let at 1*s.* to 1*s.* 6*d.* a week, except near Birmingham, where few can be got under 2*s.* 6*d.* Wages in the north, and within the influence of manufacturing towns, are always at least 1*s.* a week more than in the rest of the county. In the vale of the Tame, where the poor depend more on trade than agriculture, and where the most industrious reap considerable gain, by growing flowers and flower-roots, for sale in Bir-

mingham, a man gets 13*s*. a week and 2 quarts of beer a day. Beyond its precincts they are paid 12*s*. to 13*s*.; and men in the house, 10*l*. to 12*l*. a year; boys 3*l*. to 7*l*.

The waste and uninclosed land remaining since the date of Murray's Report has been further reduced by the inclosure of Sutton Coldfield, and Meriden Heath, besides a large central district comprising Balsall, Haseley, Beausale, Wroxhall, and Shrewley Commons. Sutton Coldfield is now the potato garden of Birmingham: immense quantities are grown by trenching the deep sands and the use of dung. Meriden Heath is the site of Lord Aylesford's farms; 200 acres of heath and bog have been recently reclaimed, and the land has been made, by high farming, to double its produce, which we may now state at 32 bushels of wheat per acre. Lord Aylesford has erected some substantial and excellent farm buildings, where the usual operations of a first-rate model farm are carried on. The system of cultivation is based on that of Norfolk, liberally carried out and assisted by a free use of artificial manures. We saw there 100 fattening oxen, scores of pigs, a dairy of 60 Devon cows, and a flock of highly fed Shropshire sheep.

A strong contrast to this are the inferior spots of land where poverty has located itself, and no generous landowner has made "the barren wilderness to smile." There is a belt of gravel and clay soil, which crosses a part of the county, lying between Knowle and Tanworth: here instead of the signs of industry and improvement, we see narrow winding lanes, leading to nothing, and traversed by lean pigs and rough cattle, broad copse-like hedges, small and irregular fields of couch, amidst which struggle the stalks of some smothered cereal—these, with gipsies' encampments, and the occasional sound of the poacher's gun from woods and thickets around, are the characteristics of the district, its soil, culture, and population.*

* The picture is severe as well as laughable, but sadly too near the truth. It is difficult to account adequately for the wildness and want of improvement often to be seen in the neighbourhood of large and even metropolitan towns; for it is true of London as well as Birmingham; and the dwellers near Sheffield, Manchester, and other great towns could probably attest the same. A band of black vegetable-gardens, reeking with town manure, environing and intersecting the suburbs, is next succeeded by coarse, undrained, irregular pasture-fields, 'divided,' it can hardly be said, by broken-down hedges, in which a few stunted pollards and tall dreary poplars serve to chill and blot the scenery, already clouded and sombre enough to the eye. This may be perhaps to some extent inevitable in the close proximity of "Land to be sold or let in building lots," in the transition state of brickkilns and gravel-pits; but it is the *next* circle to this (sufficiently described above by the author of this essay) that is the most remarkable—a circle over which the unlimited command of manure and convenience of haulage for drain-tiles and every other element of improvement, and of increased produce, might seem to warrant generous investment even upon the least promising surface, at least in the heart of a kingdom whose population has doubled and trade quadrupled in

In addition to the ordinary changes in tillage which have been referred to, we must mention the almost entire disuse of the marl-pits, which are plentiful in the western and northern parts of the county; they were formerly worked very largely, and it must be admitted a coating of marl was made a substitute for other manure; now, by a kind of reaction, this latter aid having become indispensable, the former is quite overlooked. It is said,

"He that marls sand, may buy the land;
He that marls moss, shall suffer no loss;
But he that marls clay, flings all away."

The old adage is equally true at the present day; some of the best farmers on light land regret much their distance from the pits, which if conveniently situated may be used to advantage, for marling light or peaty soils.

Another change has been the decay of the long-horned breed of cattle. The improved Leicestershire breed was originally founded by Mr. Webster of Canley, near Coventry, from whose stock, originally brought from the banks of the Trent and crossed with Lancashire and Westmoreland bulls, Bakewell and the other leading men selected. The largest and best herd was that of Mr. Burbery of Wroxhall (lately deceased), consisting of upwards of 30 cows; there are others in the county, but they are seldom pure in breed. Those, however, of Mr. Warner of Weston-in-Arden, Mr. Joseph Burbery of the Chace Farm, Kenilworth, Mr. Canning of Sherborne, and Mr. Twycross of Canley, may be named as the principal herds at present. The causes of their gradual abandonment seem to have been that the short horns come earlier to maturity and give more milk; added to which they were found, about twenty years ago, to be unprolific, and became very liable to slip their calves. They are quick feeders, and the beef is of excellent quality, but butchers dislike them on account of their tendency to lay on meat on the

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the last 40 years, and whose capital and industry penetrate with lavish enterprise every habitable corner of the earth. The exquisite home-timidity of English (*not British*) capital, the straining at the gnat upon the narrow acreage of our own little island, and the swallowing of the camel that bears our wealth and long-credits across every ocean and continent and desert, might furnish fine contrast upon some spots to be seen within ten miles' earshot of the Birmingham gun-proof house, upon wild heaths darkened, but not fertilized, by the proximity of the "central metropolis of England," the very heart of the "world's workshop." What must be the occasional reflections of Mr. Sheriff Mechi upon the stir and comments made about the few thousands spent in the redemption of a farm at Tiptree Heath, compared with the trade investments and commercial ventures with which his metropolitan experience is probably familiar! The subject deserves a thorough raking out: for the causes lie deep, and some of them hidden, some perhaps swaddled and smothered in prejudice. Very likely a young law student, thoroughly conversant with the words "entail," "feudal tenure," "land transfer," "*succession*," could, after all, tell us most about this important but neglected subject.—

outside first. Among their good qualities, their milk is acknowledged to yield more than an average proportion of cream, and the dairies which are held in highest repute for butter and cheese, are of the long-horned breed. Many farmers would gladly be in possession of these cattle again, could they obtain animals of pure breed.

A change needed, on farms depending chiefly on the dairy, is to alter the course of cropping, taking fewer corn and more root crops. Cabbages are neglected, whereas on dairy-farms they would be very useful; mangold—generally a sign of active cultivation—is very little grown in Warwickshire.

Leases are quite uncommon. Although no great spirit of improvement can as a rule be anticipated without a lease or a compensatory provision for permanent improvements, it must be admitted that theory on this subject is often put to flight by experience. Nor is this a matter to complain of. We may, on the contrary, feel thankful that, in a matter of personal interest, men can be amicably united by the ties of mutual confidence and good faith, of which this county furnishes an instance in the cordial understanding between landlords and their tenants usually subsisting.

Mr. Murray says the farmers of Warwickshire are a "sly, jealous set;" we are happy to say that these qualities, together with many usual concomitants of bad husbandry, are rapidly disappearing; and instead of being opposed, as he sometimes was in his inquiries, we were received during our survey with hospitality and cordial assistance. The business of farming is singularly free from what in other occupations are called trade secrets; and where the husbandry itself is good, there is generally a perfect willingness to explain matters to all who are concerned. The shyness with which the inferior class of cultivators answer all inquiries is a sufficient proof that, if their prejudices keep them in the old beaten track, they are yet aware of the error. There are still, in clay districts, a considerable number of small occupiers, holding farms of 100 to 150 acres, which are undrained, ill cultivated, producing couch instead of corn, supporting little labour, and thus robbing the community of one of the best employments of its capital, viz., in the wages of the Industrious Labourer.

XVII.—*On the Construction of Labourers' Cottages.* By T. W. P. Isaac, Terrace Walks, Bath.

Prize Essay.

Introductory Remarks.—It is to be deplored that most of the schemes for the social education of the agricultural labourer have not met with the success which they deserve. This, no doubt, has arisen from the fact that these well-meant efforts have too often assumed the form of charity, and thus the honest feeling of independence, which should everywhere exist, has been well nigh lost.

The greatest assistance that can be rendered to the labourer is to induce him to help himself; and we know of no way in which this can be more effectually accomplished than by affording him a suitable residence.

It cannot be denied that there exists a very intimate connection between bad dwellings and bad tenants; and it is equally certain that as the class of the dwelling is raised, the character of the inhabitant is also improved.

In Chadwick's Report on the Sanitary Condition of the Labouring Population, 1842,* there is a letter from the chairman of the Bedford Union (see p. 262). In this, speaking of the beneficial influence which improved dwellings produce on the moral habits of the inmates, he says:—

"I have much pleasure in saying that some cases of the kind have come under my own observation, and I consider that the improvement has arisen a good deal from the parties feeling that they are somewhat raised in the scale of society. The man sees his wife and family more comfortable than formerly; he has a better cottage and garden, he is stimulated to industry, and, as he rises in respectability of station, he becomes aware that he has a character to lose. Thus an important point is gained. Having acquired certain advantages, he is anxious to retain and improve them; he strives more to preserve his independence, and becomes a member of benefit, medical, and clothing societies, and frequently, besides this, lays up a certain sum, quarterly or half-yearly, in the savings' bank. Almost always attendant upon these advantages, we find the man sending his children to be regularly instructed in a Sunday, and, where possible, in a day school, and himself and family more constant in their attendance at some place of worship on the Lord's day.

"A man who comes home to a poor comfortless hovel after his day's labour, and sees all miserable around him, has his spirits more often depressed than excited by it. He feels that, do his best, he shall be miserable still, and is too apt to fly for a temporary refuge to the alehouse or beershop. But give him the means of making himself comfortable by his own industry, and I am convinced by experience that, in many cases, he will avail himself of it."

A letter from the clerk of the Stafford Union in the above

* We cannot too strongly recommend this admirable Report to the notice of all owners of cottage property.

Report (p. 263), offers further confirmation of the foregoing views.

After speaking of poverty, misery, and degradation as concomitants with the wretched hovels of the poor in that neighbourhood, the writer draws the following contrast of the state of the iubitants of improved dwellings:—

"On the contrary, on entering an improved cottage, consisting on the ground-floor of a room for the family, a washhouse and a pantry, and three sleeping-rooms over, with a neat and well-cultivated garden, in which the leisure hours of the husband being both pleasantly and profitably employed, he has no desire to frequent the beershop or spend his evenings from home; the children are trained to labour, to habits and feelings of independence, and taught to connect happiness with industry and to shrink from idleness and immorality."

These are but two of many opinions expressed by individuals whose pursuits enable them to form correct conclusions on this subject. Their collective judgment appears to be, that the first and most effectual method of elevating the labourer, is to provide him a comfortable home at a moderate rent.

To offer a few hints and suggestions for the provision of a better dwelling for the labourer is the object of this paper.

General Views as regards the character of a Labourer's Cottage. —Before proceeding to the arrangements and details connected with this subject, we would state our general views as regards the character of a labourer's residence. Although many benevolent persons have erected cottages and let them at sums that scarcely pay 2½ per cent. on their outlay, yet, as a general rule, we may be sure there will be no lasting improvement in dwellings of this class, unless they yield a remunerative interest.

We have been guided by this principle in preparing the accompanying plans. We believe that no labourer can afford more than 5*l.* a year for his house; and we consider investments of this character should bear a gross interest of 6*l.* per cent. We, therefore, have curtailed our design, so that the cost shall not exceed 85*l.* a cottage.*

To the eye of taste our elevations may not appear sufficiently ornamental; but it should be remembered that we have not sought for architectural effect, but have endeavoured to combine comfort with economy.

The introduction of gothic gables, verge boards, and gable windows, would, we are aware, have been productive of a far more agreeable elevation. But, at the same time, we fear that these advantages would be dearly purchased when we consider that by such an arrangement the comfort of the inmates would be lessened

* It will be observed that the plan does not include the usual appendage of a pigstye, so generally thought desirable for agricultural labourers.—Ed.

and the expenses increased; for these gables cause constant leaks, and the sharp gothic roof renders it necessary that the bedrooms should be partly constructed in the roof, by which their cubical contents are diminished and ventilation rendered more difficult.

But if the builder is prepared to incur the further cost, the domestic conveniences of the accompanying design may be adapted to a more tasteful and attractive elevation. (See elevation B.)

We would suggest that the best plan of erecting cottages is to build them in detached pairs, such an arrangement being cheaper and warmer.

In connection with each pair there should be about a quarter of an acre of garden ground; the same should extend before and behind the cottage. It is advisable to have a front garden and back yard (the latter being entered from the back kitchen), containing a privy, liquid manure tank or covered cesspool, and a place for dust and ashes.

We would strongly advise that proprietors should never intrust to their renting farmers the erection of labourers' dwellings. The injurious results of such a reprehensible practice are clearly visible in those miserable hovels which are dignified by the name of cottages.

Arrangement of Rooms and Internal Fittings.—In the arrangement of the rooms we will commence with the chamber-floor; and here we would suggest that it should be essential to provide every cottage with three bedrooms, such an arrangement being absolutely necessary to preserve decency and morality.

It has been well observed by a recent writer * that—

> "One crying evil prevails—want of proper sleeping accommodation for a family. Many cottages have only one, few more than two sleeping-rooms, often to accommodate a man and his wife, and growing-up sons and daughters. How under such circumstances can the rural population be expected to grow up in habits of decency, morality, and virtue? And how can we wonder at the amount of vice and immorality which unfortunately prevails?"

The size of these rooms forms the next consideration. No bedroom should either be formed wholly or partially in the roof, or have a less cubical content than 500 feet. The allowance in hospitals is 1000 cubic feet of air for each occupant, in prisons and unions 500. The contents of the bedrooms of the accompanying plan are $8 \times 9 \times 8 = 576$ feet for the smaller ones, and $12 \times 12 \times 8 = 1152$ feet for the larger ones.

In the arrangement of the ground-floor the door of the living-room should not open at once on the outer air, but should, if possible, lead into a kind of entrance-passage or porch. No dwelling can be warm where this, or a similar arrangement does not exist.

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* Sturge on the Farming of Somersetshire, p. 173.

The pantry should not communicate directly with the wash-house or scullery, since the food contained in the former would be rendered unwholesome by the operations carried on in the latter. A receptacle for coal should be constructed under the stairs, within easy access from the living-room.

Relative to the arrangement of rooms, &c. in labourers' cottages, Mr. Loudon says*—

"The door to the front kitchen or best room should open from the porch, and not from the back kitchen, which, as it contains the cooking utensils and washing apparatus, can never be fit for being passed through by a stranger, or even the master of the family, where proper regard is had by the mistress to cleanliness or delicacy.

"When there is not a supply of clean water from a spring adjoining the cottage, or from some other efficient source, then there ought to be a well or tank partly under the floor of the back kitchen, supplied from the roof, with a pump in the back kitchen for drawing it up for use."

By placing the tank or well under the back kitchen, we both preserve the water from frost and save the labour of carrying it.

The stairs should rise from the entrance porch or lobby, so that the bed-rooms may be approached without passing through the living-rooms; the convenience of such arrangement in case of sickness or death must be apparent.

In the internal fittings a contrivance (see Fig. in the accompanying Plan, No. 4), which is attended with small expense, might be introduced. It consists in merely turning the shutter into a table; when the latter is not required it can be let down, and it is then entirely out of the way.

There is one somewhat important fitting of a cottage to which we would briefly advert, namely, the window.

We have specified for oak frames with wrought-iron casements as the most easily obtained; but at the same time we think that the cottage-window invented by Messrs. M'Culloch and Co. of Glasgow is preferable.

The committee of the Highland Agricultural Society appointed to consider the means of improving the lodging of the peasantry gave much attention to the subject. They offered a premium for the best description of cottage window, and awarded the same to the one invented by M'Culloch.

"The window for which the premium was awarded to Messrs. M'Culloch and Co. is extremely simple in its construction, and may with safety be pronounced efficient in point of comfort and utility; while the price, it is believed, will be not higher than the cheapest description of iron windows now in use, and for durability will be preferable to those of any other material. The dimensions that have been recommended for the windows of ordinary cottages are 39 inches for the height, and 24 inches to the width, within the wooden frames. The size of glass required for these frames is 7½ by 5½ inches. The

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* Chadwick's Sanitary Report, p. 397.

sash is divided into two unequal parts, the lower part having three squares in height, and the upper part two. The lower part is permanently fixed, while the upper part is constructed to turn in the vertical direction on pivots, which are situate in the line of its middle astragal; and both parts are set in a substantial wooden frame, which may be either built in while the wall is erecting, or may be set in afterwards in the ordinary way with or without checked rabots, according to the taste of the proprietor. The window and its arrangements will be better understood by reference to the sketches, where Fig. 1 is an inside elevation, Fig. 2 a plan, and Fig. 3 a vertical section, in each of which a portion of the wall is exhibited, and the same letters refer to the corresponding parts in each figure; *a* is a portion of the surrounding wall, *b* the wooden frame of the window, *c* the lower sash, which is dormant, and *d* the upper and moveable sash. In Fig. 3 the upper sash is represented as open for ventilation; when shut the parts of the opening sash cover and overlap the fixed parts in such a manner as to exclude wind and water, but when ventilation is required the arrangement of the parts which produce this is such as to enable the housekeeper to admit air to any extent. For this purpose the notched latch *e* is jointed to a stud in the edge of the sash; a simple iron pin or stud is also fixed in the wooden frame at *s*, and, the notches of the latch being made to fall upon this stud at any required distance, the requisite degree of opening is secured, and when the sash is again closed the latch falls down parallel with and close to the sash. To secure the sashes when shut, the T bolt *f*, in the middle of the meeting bars, has only to be turned one-fourth round, and the moveable sash is held fast in close contact with the other.

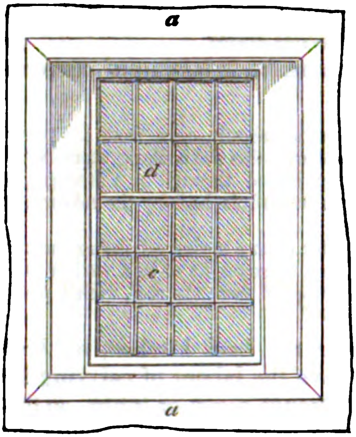
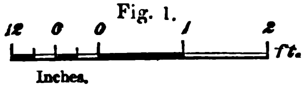
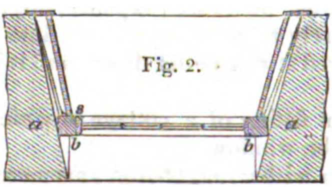


Fig. 1.





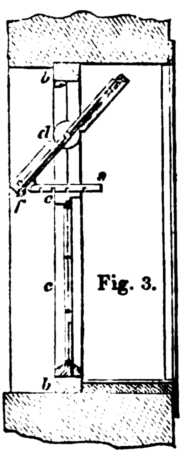


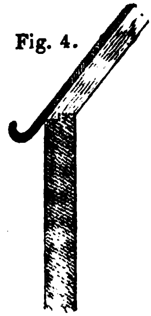
Fig. 3.

"The figures represent the window as finished up with simple dressings, viz. plain deal shutters, facings, and sole, which, at a small expense, would give an air of neatness and comfort to the apartment, and promote a corresponding taste in the other parts of the cottage.

"Though the dimensions of the window here stated may be conceived sufficient for lighting an apartment of ordinary size, they can nevertheless be varied to suit every purpose; this may be done either by employing two such windows as above described, with a mullion of wood or of stone between them, or the single window may be enlarged by one or two squares in width or in height, or in both directions."

Although it is beyond the limits of internal fittings, we may here allude to a contrivance lately patented by Mr. Beadon of Taunton, called the Patent Imperishable Eaves Gutter. It is peculiarly applicable to agricultural dwellings: it consists of the last tile being formed with a curve, as shown at Fig. 4; it is nailed to the last batten, and possesses the advantage of cheapness and of impossibility of ripping in stormy weather. It presents also a more sightly appearance than the ordinary shuting, which cannot be fixed parallel to the line of eaves, or is liable to sag between the supports.*

Fig. 4.



Economy of Heat.—One very important feature in the economy of warmth is the substitution of wood floors for stone, brick, or tile paving.

In the Sanitary Report, p. 269, the effects of using the latter materials are thus described:—

"In Berkshire the floors of the cottages are laid with red tiles, called 'flats,' or with bricks of a remarkable porous quality, and as each of these 'flats' or bricks will absorb half a pint of water, so do they become the means by which vapour is generated. The cleanly housewife, who prides herself upon the neat and fresh appearance of her cottage, pours several pails of water upon the floor, and when she has completed her task with the besom, she proceeds to remove with a mop or flannel so much of the water as the bricks have not absorbed.

"After having cleaned the cottage, the fire is usually made up to prepare the evening meal, and vapour is created by the action of the heat upon the saturated floor. Thus the means adopted to purify the apartment are equally as injurious to the health of the inmates as the filth and dirt frequently too abundant in the cottages of labouring persons."

The same objection, namely the absorption of moisture, does not perhaps apply so strongly to stone as to brick floors; still it should be borne in mind that stone is a more rapid conductor, and consequently absorbs a larger portion of heat than brick.

The ground-floor should be at least 6 inches above the level of the surrounding soil, and a layer of slate bedded in cement, or gas-tar and pitch, should be laid at that level round the walls to prevent the damp rising.

The roof should project about 1 foot 6 inches, so that the walls of the cottage may be kept dry, and the radiation of heat be checked.

The fireplaces should be constructed back to back in the

* The present holder of the patent, Mr. J. B. Lawes, of St. Albans, says, "I consider the gutter-tiles more particularly adapted for cottages and cheap sorts of building, as, when once put up, they last for ever. The price of the tiles is 4*d.* each, 13 to 14 inches in length. I do not consider their cost, when fixed, is more than 5*d.* per foot; and, in fact, I have offered to put up a large quantity at that price. As in new cottages two rows of tiles can be saved, the cost of these eaves-gutters is very much less than any other."

middle of the house; by this means we greatly economise our heat.

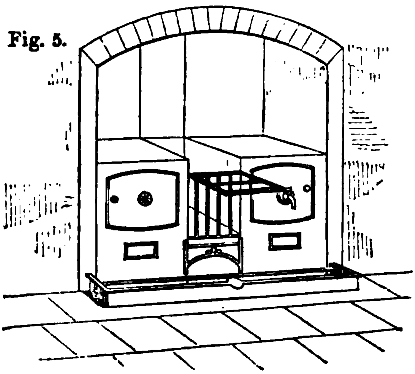
In the accompanying Plans all the flues are carried up together; this arrangement, in connection with a warming apparatus or hot-air chamber, described under the head "Ventilation," would, it is believed, supersede the necessity of fireplaces in the bedrooms.

Although thatch undoubtedly forms the warmest roof for a cottage, and is most picturesque, yet, judging from our own experience, we would advise the use of slate or tiles. We believe that the slow decomposition which frequently takes place in the thatch when in a rotten condition, produces the most disastrous effects on the health of the inmates, and often occasions fever.

We now proceed to consider the heating apparatus, and in so doing shall have incidentally to touch on the subject of ventilation, since the two are so closely connected.

We have specified for the Newark cottage range* in the living room (see Fig. 5).

Fig. 5.



The back and bottom may be formed of fire-lump, by which arrangement greater heat is obtained, and no bottom bars are required.

The door of the oven when open forms a convenient shelf, and the firebars being vertical instead of horizontal, obstruct as little of the heat as possible; whilst the smallest coals or cinders may be used.

The price of these grates varies according to their size, from 2*l.* to 4*l.*†

An ironing-stove may be added to these ranges at the cost of 3*s.* extra, provided the outside dimensions are not exceeded.

The cottage grate, manufactured by Hardy and Co., of Worcester, known as the 2 feet 10, or 3 feet oven and stove-grate, deserves attention.

This grate has a fire from 10 to 12 inches wide, has an oven

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* This grate obtained the Royal Agricultural Society's prizes at York and Exeter, and also a medal at the Great Exhibition.

† Revised prices and dimensions of the above prize-ranges complete, from July, 1853:—3 feet wide, 54*s.* 6*d.*; 3 feet 2 inches wide, 57*s.* 6*d.*; 3 feet 4 inches wide, 63*s.*; 3 feet 6 inches wide, 69*s.*; 3 feet 8 inches wide, 77*s.*; 3 feet 10 inches wide, 82*s.* 6*d.*

The above grates are also made with ovens only, and no boiler:—30 inches wide, 36*s.*; 33 inches wide, 39*s.* 6*d.*; 36 inches wide, 43*s.*; 39 inches wide, 46*s.*; 42 inches wide, 49*s.* 6*d.*

Or without the oven, but with boiler and brass cock:—30 inches wide, 42*s.*; 33 inches wide, 46*s.*; 36 inches wide, 50*s.*; 39 inches wide, 52*s.* 6*d.*

on one side, a flat or stove on the other, a draw-out stand at bottom, on which anything may be placed before the fire.

The top of the oven and the flat are level with the fire; thus in cooking the entire heat is made use of, the boilers, &c., being placed wholly or in part on the fire.

The oven is warmed partly by the heat conducted from the fire through the side, and partly by the flue under and at the side and back.

The price of these grates is from 26*s.* to 28*s.* The back is formed wholly of fire-bricks; these are not included in the cost.

In the cottage erected by Sir Stewart Menteath, Bart., at Closeburn, there is a warming-apparatus, of which Fig. 6 is a section.

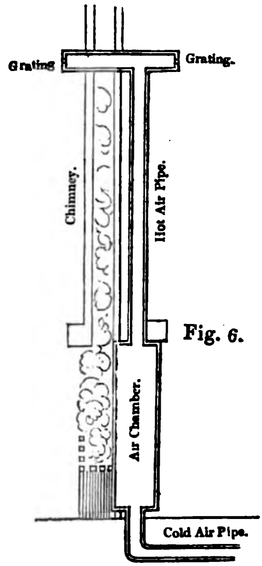


Fig. 6.

Behind the fireplace of the kitchen is an iron box. One side of this box, made of strong sheet-iron, forms the back of the fireplace. In communication with this box, or air chamber, is a pipe which admits a current of cold air. The air entering the box, and being heated by the fire, ascends through a pipe, and warms the bedrooms.

This plan, although economical of heat, is subject to one serious drawback, viz., the deterioration of the air which passes through the flue, for

"when air is warmed by contact with heated surfaces, it is liable to be deteriorated in quality if the communication of heat be too sudden and intense. The minute floccules of dust, and probably many attenuated portions of organic matter which are generally suspended in the air, and myriads of which may be seen floating in the light of a sunbeam, are decomposed at high temperatures, and their decomposition probably gives that scorched or roasted flavour which is perceived in air which has been in contact with hot surfaces.

"Metallic surfaces, on account of their great conducting power, by which they readily receive and as readily part with heat, are most apt to produce this effect on the air. It is therefore highly disadvantageous to employ such materials in any apparatus for heating, unless their temperature be kept moderate. To avoid all risk of unpleasant effects, the surfaces employed to warm air for human use should never be heated above the temperature of 107°."

Whilst adopting the principle of warming the bed-rooms by means of the fire on the ground-floor, we have taken care that the heating surface shall be of no deleterious character.

We have introduced Pearce's Fire-Lump Grate,* which consists of a hollow back formed of fire-lump, and acting as a warming chamber. This chamber receives, by means of a pipe,

* A medal at the Great Exhibition was awarded to this grate.

fresh air from the external air. Another pipe ascends to the chamber floors, and supplies them with heated air. We shall touch upon the advantage which these grates afford for ventilation when treating of the subject of ventilation. Their cost is from 30*s.* to 35*s.*

Ventilation.—The subject of ventilation is of greater importance than is generally imagined or admitted, as on it depends much of the health and comfort of the inmates; it has, however, been too much neglected in the labourer's cottage:—

"Those who are called by duty to visit the houses of the labouring classes find their powers of endurance to be more taxed, and their health more hazarded, than in the wards of a hospital rife with disease—the bulk of the population living in small rooms, frequently occupied day and night continuously by parents and children in sickness and in health; at times even by the dead as well as the living."*

The Rev. C. Walkey, of Collumpton, makes the following remarks on the same subject:—

"Cottages for the most part are without sufficient ventilation, particularly in the upstairs apartment, this being almost invariably without a chimney, with a low window, commonly about two feet from the floor, and having no ceiling; therefore the thatched roof, lofty in itself and full of cobwebs, contains the foul air; and in several instances I have been the means of restoring health apparently by blowing gunpowder in cases where fever has raged for months, the ground-floors being often damp—very seldom above the level of the land."†

It need hardly be said that a system of ventilation for a labourer's cottage should be simple in its character, cheap in its construction, and effective in its operation.

The smoky chimney too often accompanies bad ventilation; both proceed from the same cause—insufficient supply of fresh air.

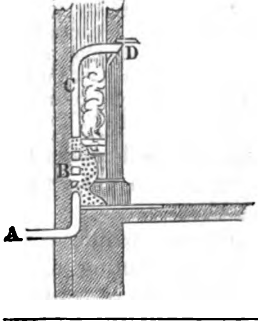


Fig. 7.

In the accompanying plans, Pearce's ventilating grates are used, which, as they draw a supply of oxygen from the external atmosphere, diminish the chance of smoking; at the same time they give to the rooms a continuous and unlimited supply of fresh air warmed to a moderate temperature over undeleterious surfaces. The operation of these grates will be understood from the accompanying sketch (see Fig. 7):—Fresh air is supplied by a pipe A to an air chamber B formed of fire-lump. This air, when sufficiently heated, passes by a pipe C through a valve D into the room. The vitiated air escapes through one of Dr. Arnott's valves E into the chimney. We would strongly advise the use of these air-traps; they can be

* Mr. Lloyd.

† Sanitary Report, p. 270.

obtained of nearly every ironmonger, at a cost of from 6s. to 12s. Dr. Arnott, in a letter to 'The Times,' dated 22nd September, 1849, makes the following remarks on them:—

"For years past I have recommended the adoption of such ventilating chimney openings as above described, and I have devised a balanced metallic valve, to prevent, during the use of fires, the escape of smoke to the room. The advantages of these openings and valves were soon so manifest, that the referees appointed under the Building Act added a clause to their bill, allowing the introduction of the valves, and directing how they were to be placed, and they are now in very extensive use.

"A good illustration of the subject was afforded in St. James's parish, where some quarters are densely inhabited by families of Irish labourers.

"These localities formerly sent an enormous number of sick to the neighbouring dispensary. Mr. Toynbee, the able medical chief of that dispensary, came to consult me respecting the ventilation of such places, and, on my recommendation, had openings made into the chimney-flues of the rooms near the ceilings, by removing a single brick and placing there a piece of wire-gauze, with a light curtain-flap hanging against the inside, to prevent the issue of smoke in windy or gusty weather. The decided effect produced at once on the feelings of the inmates was so remarkable, that there was an extensive demand for the new appliance, and, as a consequence of its adoption, Mr. Toynbee had soon to report, in evidence given before the Health of Towns Committee and in other published documents, both an extraordinary reduction of the number of sick applying for relief and of the severity of diseases occurring.

"Wide experience elsewhere has since obtained similar results. Most of the hospitals and poorhouses in the kingdom now have these chimney-valves; and most of the medical men and others who have published of late on sanitary matters have strongly commended them."

It is important that one casement in every window should be made to open, for although such an arrangement will not effectually ventilate, yet it materially assists ventilation.

It will be observed that the door between the living-room and wash-house is made to open towards the fire. The reason of this arrangement is best explained by an extract from Tomlinson's work on ventilation:—

"Chimneys which otherwise draw well will often smoke from the improper situation of a door. Thus when the door and the chimney are on the same side of the room, and the door, being in the corner, is made to open against the wall, as is usually done, to have it more out of the way, it follows that when the door is partially opened a current of air rushes in and passes along the wall into and across the opening of the fireplace, and whisks the smoke into the room. This happens more frequently when the door is being shut, for then the force of the current is increased, and persons sitting near the fire feel all the inconvenience both of the draught and the smoke. A remedy may be found by an intervening screen, projecting from the wall and passing round a great part of the fireplace, or still better, by shifting the hinges of the door so as to throw the air along the other wall."

When the bedrooms are formed either partially or wholly in the roof, their cubical content is diminished, and the difficulties of ventilation proportionably increased.

The accompanying plans are designed in accordance with this principle, no portion of the bedrooms being constructed in the

gable; consequently their cubical content is considerably above the average of cottage rooms.

Drainage.—The drainage of a pair of agricultural cottages offers but a narrow field for remarks. For first it would of course be out of our limits to allude to any extended scheme of drainage, by which a whole neighbourhood might be drained to one level, and the manure applied to purposes of agriculture.

And secondly, it would be superfluous and absurd in these days of medical and chemical science to attempt to prove that bad drainage is the prolific source of disease: our remarks must therefore be of a very practical character, and our attention confined to mere details.

We have frequently had brought under our notice the open cesspools, or dead holes, which are too frequently used.

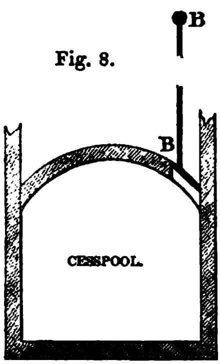
They are generally mere pits dug in the ground, and are often found to drain themselves—in doing so they saturate the whole neighbourhood with drainage matter, and give rise to the most noxious gases.

For these dead-holes we would substitute cesspools properly paved, lined, and domed with brick set in cement.

All openings into the same should be properly trapped to prevent the return of any vapour or gases.

In the accompanying plans the arrangement proposed is extremely simple.

Fig. 8.



The ground underneath the privies and ashpit is excavated to the depth of 6 feet, and lined and domed with bricks set in cement.

In the ashpit a 9-inch opening B is made in the dome of the cesspool. This opening is fitted with an iron plate and rod, and at certain intervals the plate B is pulled up, and the accumulated ashes falling down partially deodorize the soil.

A man hole fitted with a stone slab and ring is formed in connection with the same.

These privies are provided with a cheap and simple trap and basin.*

This apparatus will be effectual as long as the trap is supplied with water, but since this will increase the bulk of the sewage, it would be advisable to form a communication with some drain, by means of a drain pipe inserted within 1 foot of the head of the cesspool. This would draw off the water and leave the sewage at a uniform depth.

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* Those formed in one or two pieces of stone-ware, may be purchased at about 7*s.* 6*d.* together; allowing 5*s.* 6*d.* for fixing, &c., one privy may be effectually trapped at about 13*s.* or 26*s.* the two.

When the circumstances allow, the water from the pump may be used for the purpose of flushing the pans.

The waste water from the pump might be carried by a 1-inch lead pipe within 1 foot of the first pan, and from this 2 pipes ½ diameter should diverge.

This arrangement would flush both pans at the same time.

The best kind of trap for the sink is perhaps the bell trap, Fig. 4, in accompanying plans, which, however, may be improved by having a hinge with a projecting piece of metal, which, while it allows of the bell being partially raised by the knob B, prevents it from being thrown back and left open.

It has been well said that a man's comfort depends upon a variety of circumstances, which, though singly they may seem trivial, do really make up a large proportion of the sum of earthly happiness. We have kept sight of this principle in the foregoing remarks; believing that nothing which tends to make the labourer's cottage commodious, cheerful, and healthy, is beneath the notice of the landlord or the philanthropist. The beneficial results attendant upon a due attention to ventilation, drainage, warmth, and accommodation, are many and indisputable; results which are seen not only in the physical, but also in the social and moral character of the tenant—results of which not the least is that the labourer is thereby induced to consider his dwelling-place as his home.

SPECIFICATION of SUNDRY WORKS *required in the Erection of a pair of Agricultural Labourers' Cottages according to the accompanying Design.*

Excavator.—The foundations of the various walls and all necessary excavations for the water-pipes and drains to be taken out to the required depths, and all surface-mould taken off.

The surface of the room on the ground-floor to be excavated to the depth of 1 foot, and proper air-traps fixed for circulation of air.

The soil thus removed, and also that which may arise from all other excavations, to be distributed around the exterior, so as to give a descent in every direction from the buildings.

Mason.—Form cesspool 6 ft. deep under the privy and ashpit, and line, pave, and dome the same with 4½ in. brick set in cement.

Build the privy and ashpit in the position and to the heights shown on plans, with 4½ in. brickwork.

Form man-hole in connexion with cesspool, and cover the same with Pennant or other hard stone slab, with iron ring in same. Form hole in dome of cesspool, and fit the same with iron plate and rod, as suggested in Essay under the head "Drainage." Fix two stoneware connected closet-pans with syphon-trap at the head of soilage-pipes.

Pave the privy floors with 1 ft. square paving-tiles, 1½ in. thick.

The footings to be built with good hard well-burnt stock bricks, with close joints filled in solid and well flushed with mortar.

The mortar to be composed of well-burnt stone-lime and sharp clean sand, mixed up with a small quantity of smith's ashes in proper proportions.

A thick layer of gas-tar and pitch, mixed to a proper consistency, to be

spread hot over the horizontal surface of all the walls, and dry sand scattered over the same at the ground-level to prevent the damp rising.

The walls to be built as shown on drawing, using sound, hard, well-burnt, red bricks, with grey stocks for all angles, labels, and sills; splay bricks to be used for the plinth.

Discharging arches to be turned over all the doors and windows on the ground-floor.

The arches of the living-room and scullery fireplaces to be turned upon iron chimney-bars.

The smoke-flues to be carried up as shown on plan, 9 in. square, properly cored and pargetted with cowdung mortar.

A 4 in. socket-pipe for the supply of air to the grates to be laid from a grating in front of the cottage.

Form all the necessary flues for the ventilating apparatus connected with Pearce's fire-lump cottage grate.

A rubbed hearthstone to be laid to the fireplace of the living-room, and a brick hearth to that of the scullery, with proper back hearths, the same to be 1 ft. longer than their respective openings.

The living-room, scullery, and bedroom grates to be set with good soft fire-bricks; the brickwork of copper to be built with rounded bricks, and cased with fire-bricks where exposed to the fire.

The walls inside the scullery and pantry to be neatly pointed and stained a light stone-colour. Wood-bricks to be built into the walls as the works proceed, for the purpose of fixing the window-frames and door-jambs.

4½ in. dwarf walls, as shown on section, to be carried up to take joists of ground-flour, the same to be not more than 4 ft. from centre to centre.

A tooled flagstone, with a plain wrought-iron scraper fixed therein, to be laid in front of each porch door.

A 5 in. dished sink-stone, 2 ft. by 1 ft. 6 in., to be fixed on brick piers in scullery, and the lead pipes and air-trap, as hereafter described, let into the same.

A similar stone, with a plain wrought-iron grating let into the same, to be fixed in the front of the cottage, over the termination of the air-pipes.

Each of the windows to have a sill of Bath, or other stone, as the case may be, 9 in. wide and 3 in. thick, wrought with fair edges and ends throated and laid sloping.

Slate chimney-pieces, with jambs 6 in. wide, and shelves to be fixed to fire-places. The outer doors to have a 3 in. tooled flagstone sill 15 in. wide, mortised to receive door-frames.

Turn trimmer-arches, and provide and fix tooled stone hearths to the bed-room fireplaces.

The whole of the brickwork is to be done in manner of English bond, and is to be completely laid in, and to be entirely flushed up at every course with mortar; and the whole of the foundation-work is to be grouted with liquid mortar at every course. No four courses of the work are to rise more than 1 in. besides the height of the bricks, and there is to be no difference between the soundness and goodness of the outside work and of the inside work, no variation being allowed therein, except that the work intended to be plastered is to have the joints thereof left rough for the adherence of the plastering.

Tiler.—The roof to be covered with plain and ornamental rounded tiles, three rows of plain, and then two rows of rounded tiles, to be fixed alternately on laths 1 in. by ¾ in., with proper valley tiles and ornamental ridge or crease tiles; the gables to be finished with proper gable tiles and pointed with dark-tinted mortar. The outbuildings to be covered with Roman tiles.

Carpenter and Joiner.—The timbers used to be free from sapwood, shakes, large or dead knots, or other defects, and to be perfectly well seasoned.

The roof to be constructed with two pair of principals, with timbers of the following scantlings, viz.:—

Principals of elm, 10 in. by 4 in. at bottom, 9 in. by 3 in. at top.
Wall-plates of Memel, 4 in. by 3 in.
Purlins of Memel fir, 6 in. by 3 in.
Tie-beam of Memel, 11 in. by 3 in.
Ridge of Memel, 6 in. by 2 in.
Strutts, 5 in. by 3 in.
Kingpost, 9 in. by 3 in.
Rafters of Memel fir, 4 in. by 2 in., the same to be set not more than 16 in. from centre to centre.

The ends of the rafters, wall-plates, and purlins, to be carried 1 ft. beyond the walls, and to be faced with ¾ in. beaded boarding and finished with an ogee.

The roof of outbuildings to be formed with rafters of Memel fir; the wall-plates to be of elm, 4 in. by 3 in.

The ceiling-joist to be of yellow pine, 3 in. by 4 in., grooved into the tie-beam.

The joists of chamber floor to be of elm, 9 in. by 2½ in., chain-braced in two places, and set not more than 14 in. from centre to centre; all trimmers to be 9 in. by 3 in.; the wall-plate of the same to be of elm, 4 in. by 3 in.

The joists of the ground-floor to be of elm 6 in. by 3 in., set not more than 14 in. from centre to centre, the same to rest on dwarf walls of 4½ in. brick.

Oak lintels, 3 in. thick and 18 in. wider than their respective openings, to be fixed over all doors and windows.

The joiners' work throughout, unless otherwise specified, to be of yellow pine; the same to be stained a light oak colour and varnished.

The chamber-floor to be of well-seasoned Memel, and that of the ground-floor of well-seasoned elm, 1 in. thick, and not more than 6 in. wide, well planed and jointed; the whole to be bradded and neatly and securely made.

The staircases to be of 1-in. elm, properly housed into 1-in. drag-board, and carried up, as shown on plan, with 8-in. treads, and 7-inch risers, the same to have a strong moulded deal hand-rail with turned and mitred caps, framed and turned newels 3 in. by 3½ in., bar balustres, 1 in. square, and all other fittings and appurtenances of every requisite kind.

The boys' and girls' rooms, as well as a part of the parents' room, by the passage, to be separated by fir-quartered partitions, with quarters, heads, and sills, 3 in. by 3 in.

The external front or principal entrance doorway to be fitted with a proper fir doorcase, 5 in. by 4 in. and a four-panel, bead, flush, and square-framed door, hung with 4-in. butt hinges, two 10-in. rod-bolts, and a 10-in. iron-rimmed drawback lock with strong brass furniture.

The back doorways and the doors of the privies to be fitted with proper fir doorcases, 4 in. by 4 in., and ¾-in. deal wrought, beaded, grooved, cross-tongued and ledged doors, hung with 18-in. cross garnet hinges and Norfolk thumb-latches, and to put to the back door two 10-in. rod bolts, and to the privy door a small bolt. All other doors to be ⅞-in. battens, with three ledges at the back, hung each with a pair of 3½-in. butt hinges, the same to have a good 7-in. iron-rimmed lock, with key and strong brass furniture.

Put to all the doors the requisite linings of 1¼-in. yellow deal, single rebated.

The window-frames to be of oak, and of the description shown on drawings with ¾-in. hinges, and 1-in. window-boards with rounded edges to stop the plastering; one casement in each window to be made to open.

Skirting-boards with beading, 5½ in. by ¾ in., to be fixed in all the rooms.

Dr. Arnott's air-trap to be fixed in all the rooms, near the ceiling, in connection with the smoke flue.

A ¾-in. shutter to be hung to the front windows, with supports, so as to form a table when necessary, in the manner shown in drawings of the same.

Angle-beads to be fixed to the chimney-breasts and other angles to protect the plastering.

Two rows of 1 in. shelves to be fixed in the pantry.

A proper seat and riser with flap and hinges to be fixed in the privy.

Plasterer.—The whole of the ceilings to be lathed with best split Baltic laths not less than $\frac{3}{16}$ of an inch thick, and well broken at the joints.

The whole of the interior walls (with the exception of the washhouse) and pantry walls, as well as the ceilings, to be plastered with two coats of plaster, well hand-floated and twice lime-whitened.

Ironmonger.—A 4 in. semicircular iron shute, with iron bearers, screwed to the rafter 6 ft. apart, to be fixed to the eaves of the roof; or a gutter formed in clay, similar to that patented by Mr. Beadon of Taunton, properly glazed, and fixed with Portland cement, would answer well for the purpose.

A 2½ zinc down-pipe, with iron shoes and beads, to be fixed in the position marked on elevations.

A bell-trap of the description shown on plans, with lead-piping attached, to be fixed to the trap-stone in scullery.

Cast-iron casements to be fixed to all the windows; one casement in each to be made so as to open, with proper hinges and fastener.

A grating to be fixed over the heads of air-pipes, in stone fixed for that purpose in the front of the cottages.

Three cast-iron hat and coat hooks to be fixed in the entrance-passage.

A proper copper to be fixed in back kitchen, with stove for heating water.

Fix in the living-room a 33-in. Newark cottage-range. In the wash-house Pearce's fire-lump grate for heating two rooms at once, of the value of 35*s*. Fix all the necessary flues, valves, &c. required for the ventilating and warming connected with Pearce's grates.

In the parents'-room Pearce's fire-lump grate of the value of 15*s*. 6*d*.

To provide and fix in the garden against the cottage a strong, sound, and good wine-pipe to serve as a waterbutt, and to put thereto ¾-in. lead pipe leading from the waterbutt to the sink, and to put to the water butt two good brass cocks, one to draw water at the sink, and the other to draw water in the garden.

Plumber, Glazier, and Painter.—All the lead necessary for the roof to be 6 lbs. to the superficial foot.

1-in. lead pipe from trap in scullery to be laid to the most convenient level.

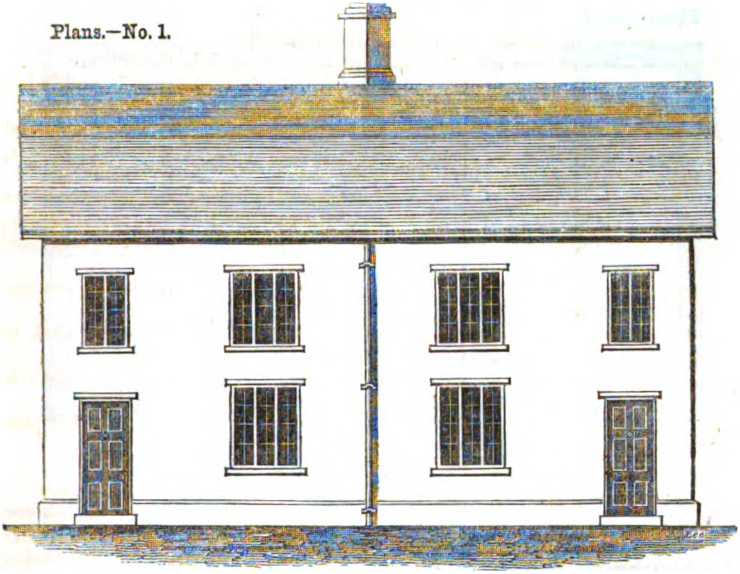
The whole of the windows to be glazed with seconds Newcastle crown glass.

The whole of the wood-work not stained, as well as all iron-work, to be painted four times in oil.

General Conditions.—The contractor is to perform the whole of the works in the very best manner, with the very best and the most approved materials and labour of their respective kinds; he is, under the direction of and to the entire approbation of the architect, to provide, fix, and execute all works which are specified, represented, or implied in or by this specification, or in or by the drawings thereby referred to or either of them, or which may be requisite for rendering every part of the buildings, works, and appurtenances complete, and to make good all damage caused by the execution thereof, without any charge of any kind thence arising and becoming due, except the amount of the consideration of the contract; and the architect is to have power to order any alterations in the form of the structure or of the finishers thereof without vitiating the contract, and the difference of expense (if any) caused by any such alteration so directed shall be ascertained after the rate of the schedule of prices hereto attached; and if such schedule be found in any manner deficient, then the aforesaid architect is to calculate and determine such additional prices as may be requisite, the same being after the same rate of cost and profit as those contained in the said schedule.

Remarks on Estimate.—The estimate of cost is framed on the supposition that bricks can be obtained at 25*s*. per thousand, and that the price of other materials and labour would be in the country 10 per cent. below the London prices.

Plans.—No. 1.



ELEVATION A.

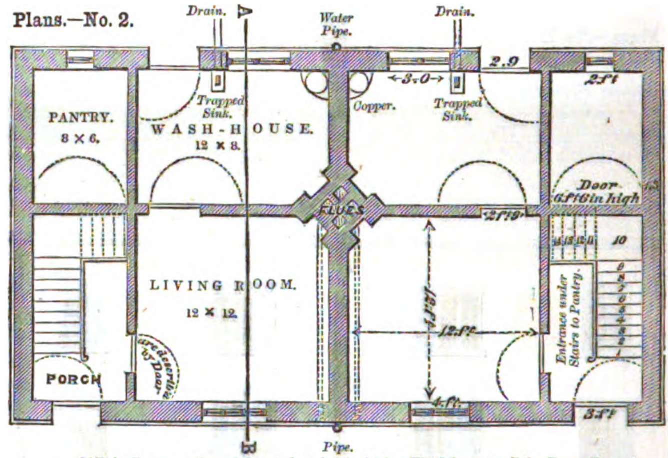
ELEVATION B.

NOTE.—The ELEVATION A is the one to which the accompanying Plans and Specification more particularly refer, and on which the Estimate of Cost is framed.

The ELEVATION B could be used with same arrangement of Rooms in the Ground and Chamber Plans, with the exception of the Living and Parents' Rooms being brought out 1 foot, so as to give a break at C and D. This Elevation would cause an increase of 25*l.* in the cost of erection.

Scale, 1-8th of an inch to a Foot.—Estimated Cost 170*l.* the pair.

Plans.—No. 2.



[All the Rooms on Ground-floor to be 8 ft. 6 in. high.—Wood floors to all the Rooms.]

GROUND PLAN.

NOTE.—The arrangement of Rooms in this Plan offers (among others) the following advantages:—

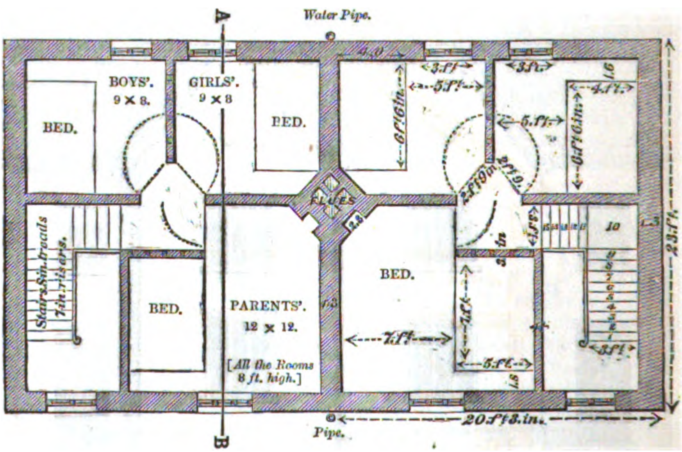
1st. The Porch or Entrance prevents the cold draughts which are the certain consequence of the door of the Living-room opening at once into the air.

2nd. The economy of heat resulting from the arrangement of the Flues.

3rd. The separation of the Pantry from the rest of the House, so as to afford a repository for Meat, &c., free from the steam of the Wash-house or the fumes of the Living-room.

4th. An easy, light, and wide Stairs.

The length of the building might be curtailed 4 feet, by taking from the Porch 1 foot, and narrowing the Living-room 1 foot; this would decrease the cost about 8*l*.



CHAMBER PLAN.

NOTE.—Some of the advantages of this arrangement are:—

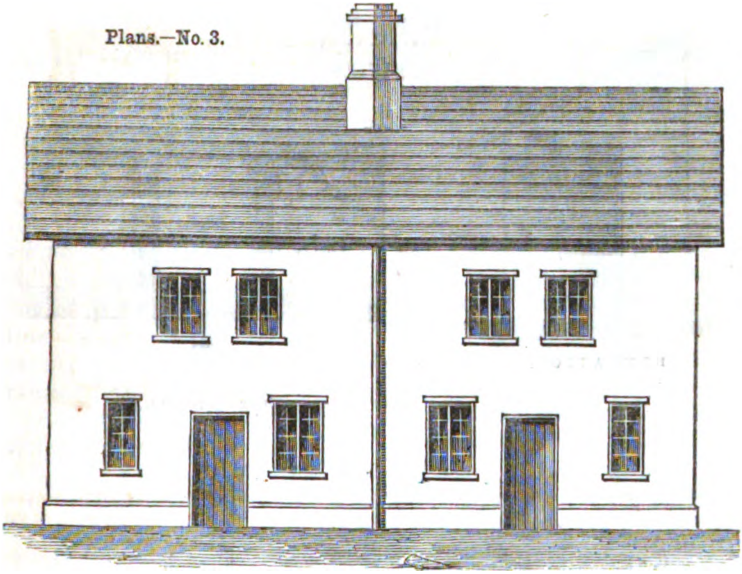
1st. The division of the Sexes, so essential to decency and morality.

2nd. Each of the smaller rooms contains 576, and the Parents' room 1152 cubic feet, which is a much larger allowance than usual.

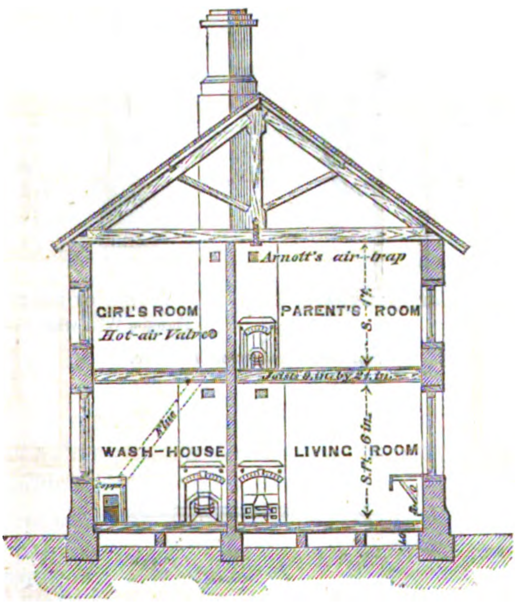
3rd. By the arrangement of the Flues great economy of heat is obtained; and by the use of Pearce's Cottage-grate the Girls' rooms are sufficiently heated and ventilated by the fire in the Wash-house.

Scale 1-8th of an inch to a Foot.—Estimated Cost 170*l*. the pair.

Plans.—No. 3.



BACK ELEVATION.

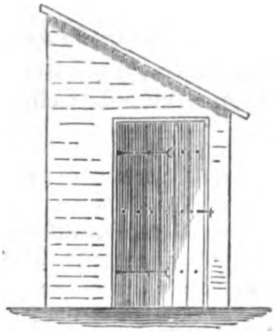


SECTION A TO B.

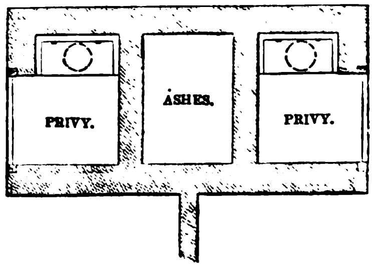
Scale 1-8th of an Inch to a Foot.—Estimated Cost 170*l*.

Plans. — No. 4.

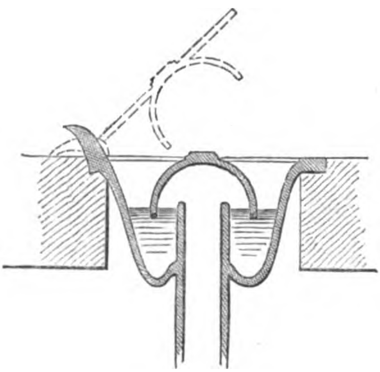
PRIVIES.



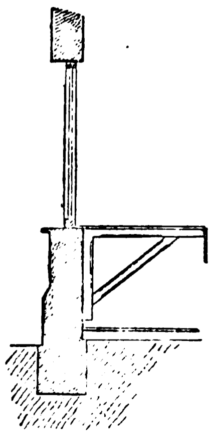
ELEVATION.



GROUND PLAN.



SECTION OF BELL-TRAP.



SECTION OF SHUTTER,
Forming Table when required.

Scale of 1-4th of an inch to a Foot.

XVIII.—*On the Natural History of British Meadow and Pasture Grasses.* By James Buckman, F.G.S., F.L.S., Professor of Geology and Botany in the Royal Agricultural College, Cirencester.

The following description of meadow grasses is meant to apply for the most part to such species as are of importance to the farmer, from making up a part of the ordinary pasture in different soils and situations; at the same time remarks will not be wanting on those species which either from their bad qualities as pasture grasses may be considered as pastoral weeds, or from occurring to a considerable extent under tillage may be denominated agrarian weeds.

As regards the relative value of the pasture grasses, there must always be some difference of opinion, arising from difference of soil, climate, and other external causes, which certainly exercise great influence, and cause a wide diversity of result. I can therefore only say, on behalf of my own observations, that they are the result of many years' study of this useful tribe of plants, which I have pursued not only as a botanist, but as one thoroughly alive to their agricultural bearing and importance. Not only have I carried on this study in the field, but I have also kept most of the species in cultivation for many years, and have made them the subjects of practical experiments in reference to their growth, yield, and some of the chemical details connected with them.

It should be remarked that this paper has not been burdened with descriptions of all the grasses, as many of them, though curious in a botanical point of view, are yet without agricultural interest, and their consideration would have too greatly increased the length of this paper.

References.—A refers to an *annual* grass, or such as dies when it has produced its first crop of flowers.
B, *biennial*, such as flower two years, and then die.
P, *perennial*, such as flower for several years.

A.—Stamens, 2. Styles, 2.

Anthoxanthum—*panicle* spicate, *glumes* unequal, *glumel* double, outer one with short awns.—P.

A. odoratum—sweet vernal grass—is the only agricultural species in this division; it is a very early grass, being one of the first to flower, and is well known for its peculiar fragrant odour, which is more apparent in the dried than in the green specimens: it is the presence of this grass which imparts most of the grateful smell and flavour to meadow-hay, and which in all pro-

bability renders it not only more palatable but also more nutritious than seeds or artificial hay.

Its bulk is small, so that it adds but little weight to the rick, and its short leaves are incapable of affording much *aftermath;* still its fragrance entitles it to a place in all mixtures of grasses in laying down permanent pasture.

B.—Stamens, 3. Style, 1.

Nardus—*glume* absent, *glumel* of two valves, *spike* unilateral.—P.

N. stricta—heath-grass—occurs on damp heaths or marshy places, and is readily distinguished by its slender unilateral spike with flowers all pointing one way. Of no agricultural value, except as indicating the nature of its soil.

C.—Stamens, 3. Styles, 2.

† *Flowers spiked.*

Alopecurus—*glumes* nearly equal, united at the base; *glumel* of a single valve, awned from below; *spike* compact.

1. *A. pratensis*—meadow foxtail—spike cylindrical, blunt at the apex, about 2 inches in length.—P.
2. *A. agrestis*—taper foxtail—spike cylindrical, pointed at the apex, from 2 to 3 inches long.—A.
3. *A. geniculatus*—floating foxtail—spike cylindrical, blunt at the apex, about half the size of A. pratensis.—P.

The Alopecurus pratensis is a common native grass, especially in moist meadows and in deep rich pastures, for which situations it is admirably adapted, as it yields a large proportion of hay and a quick growth of aftermath; it should always form part of the grass for irrigated meadows, as it is very early and bears cropping well, sending up culms and a plentiful supply of herbage for the second or hay crop, after the first depasturing by sheep.

As a grass for self-cultivation, it may be stated that it grows fast even on a medium soil and in exposed situations, and its upright habit would point it out as no bad species to mix with rye-grass in "seeds," whilst in laying down land for permanent pasture it should always take a place with other grasses.

The Alopecurus agrestis is sometimes called the *black-bent*, at others *hunger-weed*, terms expressive of the low estimation in which it is held, and the poor agrarian land in which it delights to grow. Sinclair says, "the appearance of the black-bent among wheat is a certain sign that the crop will be worthless." It is

seldom found in the open meadow, but is mostly an accompaniment of strong heavy land which has been badly tilled and is much out of condition; its presence therefore denotes a want of drainage and liberal manuring, which treatment, as we have frequently witnessed, will eradicate it even in a single season.

A. geniculatus is here noted as a denizen of wet places, where, if cattle can get at it, they invariably keep it well cropped down. In some situations it appears in a stunted condition, apparently on dry soil, but this is only after drought, as, if it be not surrounded by water for a great part of the year, it soon dies out; under such circumstances, therefore, it is an indicator of some value.

PHLEUM—*spike* compact, *glumes* distinct, *glumel* of two equal awnless valves.

P. pratense—timothy or catstail grass—glumes equal, much truncated, with long produced points, each valve ciliated with a row of stiff hairs on the back.—P.

This grass, under the name of catstail, is a common native, found everywhere in tolerably good pastures. It has been introduced among most others of our British pasture grasses to the American continent, where it appears to have attracted the attention of one Mr. Timothy Hanson, who probably first brought it out as a self-grass, in which cultivated form it has become associated with his Christian name; and hence the idea that some entertain that we got the species from America is erroneous, as it is not indigenous to that country, though it is quite true that we import from the States and Canada most of our seed under its name of timothy-grass.

As a meadow-grass, it is to be recommended for the mass of its nutritive culms, which are anything but coarse with us, and especially in our hay season, as it is a late species; it however yields comparatively little aftermath.

As a self-grass, its cultivation has never been carried out to any extent in Britain. In the United States, however, and Canada, hundreds of acres may be seen occupied with the cultivated form—timothy-grass; and on the alluvial flats of the Ohio, and the broad alluvial lands left by the contraction of the American lakes, this grass yields enormous crops, with spikes of flowers sometimes as much as six inches in length.

It is a grass easy of cultivation, and particularly well adapted for growth on river flats or estuarine warp-land, on which it will yield much larger crops than any other grass, and, though somewhat harsh and coarse in such places, will yet be found to contain highly nutritive qualities, and is peculiarly adapted for admixture in chaff.

There are several other species, but they have no particular agricultural value.

AMMOPHILA—*spike* compact, *glumes* of nearly equal pointed valves, with a tuft of hairs at the base, including the *glumel.*—P.

A. arundinacea—sea-reed, mat-grass—remarkable for its creeping rhizome, which we have obtained of as much as 30 feet in length. It is a common denizen of the sea-side, and, from its peculiar growth, it operates very beneficially in keeping together the sands of the coast, on which account it is carefully looked after and preserved by Act of Parliament. It may be worth a trial in some of the deep railway cuttings, especially where these occur in sandy clay, which renders them peculiarly liable to give way either from the rain of the wet season or the cracking which succeeds from the drought of summer. It is readily cultivated by joints or cuttings of the rhizome.

It is of no agricultural value, as its coarse, rigid, sapless herbage is untouched by cattle.

PHALARIS—*glumes* of erect equal keeled valves, including the *glumel*, which adheres to and becomes part of the seed.

P. canariensis—canary-grass—flowers in an oval spike—an annual grass, occurring in waste places and about the homestead, and probably introduced from its use as a food for canaries and other small birds, on which account it is cultivated in the neighbourhood of London and some of our larger towns for its seed. Its cultivation is exceedingly easy, a light soil with a fine "tilth" being almost the only condition required. We have seen good crops on both elevated and low lands, as it is a grass which endures great variations of climate.

P. arundinacea—reed canary-grass—flowers more or less densely paniculate. A perennial species, usually growing in water, in which it extends rapidly by its thick rhizome. Its occurrence in hedge-rows and meadows is a sign of great damp, which would be improved by drainage, when the species soon dies out. It is of no agricultural use; its rhizome, however, occasionally renders it of value in keeping up river-banks; but it is oftener injurious, as spreading into watercourses, and thus vitiating a system of drainage by arresting the equable flow in the main or trunk channels.

†† *Flowers paniculate, more or less lax.*

AGROSTIS—*glumes* of two unequal valves longer than the *glumel*, the inner valve of which is sometimes absent, the outer either awned or awnless.

Agricultural forms.—Fine bent:—

1. *A. vulgaris*—head of flowers spreading, exceedingly light and elegant; *stolons* more or less creeping, whole plant smooth. Hab., upland meadows and pastures.—P.

2. *A. vulgaris, var. alba*—marsh-bent—head of flowers larger and more compact; culms rooting at the lower nodes, and sending out *stolons;* whole plant more or less rough, and stouter than the preceding. Hab., ditches and wet places.—P.

3. *A. vulgaris, var. stolonifera*—agrarian bent—head of flowers much congested; stolons above, rhizomes creeping below, the ground. Hab., stony places; mostly an accompaniment of agrarian conditions.—P.

These three forms are proved to belong to the same species, as from cultivation we have obtained the following results:—

A plot of A. vulgaris, sown in 1855, presents the usual delicate form of this grass, with a tolerable admixture of both *stolonifera* and *alba.*

A plot of A. stolonifera. The general plant is A. vulgaris, having a few *stolonifera* intermixed, which latter present more of the true *alba* form than the congested flowers and stolon growth of its proper type. These experiments, though they tend to confirm their specific identity, by no means confound the different agricultural value of the three forms; and indeed, agriculturally, varieties themselves are of equal value with true species.

These varieties mark different agricultural conditions; and though neither of them are of great use as pasture-grasses under ordinary circumstances, yet the peculiar method of growth of the *A. stolonifera,* united with the fact of the great increase both in quantity and quality of its herbage under irrigation, point it out as a grass well adapted to form part of the produce of an irrigated meadow. As an agrarian, however, it is usually known by the name of *squitch;* and its small, wiry rhizome renders it exceedingly difficult to eradicate, especially from brashy land, which is its favourite habitat, and in which it spreads so fast, that a summer fallow becomes so literally choked up with it as almost to exclude every other form of weed, if we except Triticum repens—common couch—which is its usual congener.

** *Spikelets with mostly two perfect florets.*

MOLINIA—*panicle* contracted, not spicate; *glumes* acute.

M. cœrulea—purple melic-grass. A species remarkable for its solid stem and few nodes; it has long wiry roots, by which it mats together the humus soils of peats and moors; it is of no value in pasture, but is always an index of want of draining and general amelioration, under which it immediately disappears. —P.

CATABROSA—*panicle* spreading; *glume* of two obtuse valves, including the two or three florets; *glumel* truncated, awnless.

C. aquatica—water-whorl-grass. It is a perennial water-grass, and its only British species will be found in ditches, water-courses, and ponds, where it frequently grows very luxuriantly, and is remarkable for a peculiarly sweet licorice flavour, on which account cattle crop it down very closely whenever they can reach it; it is, however, so purely aquatic—refusing to grow away from water—that nothing can be done in its cultivation. A dwarf variety will frequently be found on mud-banks; but here it is an evidence of their wetness.—P.

AIRA.—*glume* of two unequal valves, including two perfect florets, which are usually awned from near their base.

A. cæspitosa—turfy hair-grass—hassock or tussac grass.—Of this genus there are several species, but only this one will need description here: it is distinguished by its tall stem, panicle-spreading; flowers numerous on slender pedicels, having their outer glumel awned; leaves long and pointed, with serrated margins and roughened ribs, which makes this grass very rigid and objectionable to cattle, on which account, and from its possessing but little nutritive matter, they commonly object to eat it unless when quite young. It is found constant to two positions—moist damp woods, under the trees, where it forms an excellent covert for game. Its more objectionable habitat is in undrained meadows, or where there is a chance of water stagnating; and hence it is interesting as marking want of drainage, the stoppage of a drain, of a grip not well opened, or a want of free exit for the water in any part of a water-meadow. If any of these conditions continue for a length of time—sometimes incredibly short—this grass soon assumes its large cushion-like growth, from which it has attained the country names of hassock or tussac grass, bullpates, &c. It establishes itself in separate masses, like the larger jungle grasses of the tropics, which soon overpower all other species. Where present a meadow can never be perfect; if in irrigation, the wet "swag" must be relieved by an additional grip or channel into the exit-drain. In the meadows, with proper draining, its disappearance is equally rapid with its former growth.

HOLCUS—panicle lax, florets soft with downy hairs; *glumes* of two nearly equal two-flowered valves; upper floret awned, lower one awnless.

H. lanatus—meadow soft grass; awn short and curved back-

wards, so that it is seldom exserted beyond the glumes; its upper end only is rough; plant not creeping.—P.

H. mollis—creeping soft grass; awn nearly straight, always exserted, rough along its whole length; plant creeping on the surface of the ground.—P.

The first of these is usually found growing in damp meadows near rivers, being a general grass under flooding, but not so under proper systematic irrigation. It is quite useless, possessing neither flavour nor nutritive qualities, and much deteriorates meadows in which it abounds. The best method for its eradication will be found in the adoption of such farming as will suit better species; the law of extermination of the weaker by the stronger being nowhere so apparent as in the grass meadow; for if the circumstances prevail which suit those of a good kind, any bad ones either die out or linger on in a wretched and abject state; but a return to poverty, or a starved condition of the soil, soon causes the bad ones to obtain the ascendancy, and drive out those of a better quality.

The H. mollis is almost confined to sandy soils, such land as is formed from the disintegration of the conglomerates of the old red, and the more arid tracks on the new red sandstones, and the grits accompanying coal-measures are peculiarly liable to it. It spreads in most dissightly tufts in the meadows on such soils, and, from being of no value itself, it is a great pest in the meadows. It is best kept under by well harrowing it from the rest, and following this process with marling and manuring, which may be done with any substance tending to fertility, as it is a grass unknown in rich pastures. Johnston, in his 'Natural History of the Eastern Borders,' remarks that, "when a field of light shallow soil, after being cultivated for a few seasons, is again laid down for grass, an abundant and unlooked-for crop of this grass will often appear. It is one of those cases in which we are left to wonder how the seed came there."—(p. 212.) But we need not wonder how this or its congener spreads and gets into cultivation, seeing that each in its own locality is ever found about the homestead, and one plant seeding is enough to stock a wide space of ground. The sweepings of waste places, when they are thus cared for, find their way to the muck-heap; and from this, agrarian grasses and other weeds are continually being very industriously and equally spread over the land.

ARRHENATHERUM—*panicle* lax, *glumes* of two valves, and two florets, the lowest of which has a long twisted awn, the upper one a short bristle on the outer glumel, lower floret with stamens only, upper one perfect, *i.e.* with stamens and pistils.

A. avenaceum—oat-like grass—a tall species, growing much after the manner of the oat, to which its trivial name of oat-like has reference; both its culms and aftermath are usually produced in abundance; but it possesses an exceedingly bitter taste; and though Sinclair says "it is eaten by all sorts of cattle," yet we have uniformly noticed that cows and sheep refuse it unless starved to it by want of something better. "It contains too large a proportion of bitter extractive and saline matter to warrant its cultivation without a considerable admixture of different grasses; and the same objection extends to its cultivation in permanent pasture," according to the author just quoted; but as he finds it "always present in the composition of the best natural meadows," so he concludes that it should have a place in the list of species for the laying down of permanent pastures. However, from a long observation of this grass, both in separate plots and in the meadow, we are inclined to think that it would be better to discourage its growth; it may indeed be seen in the good meadow, but it is best grown in the worst parts thereof, and, from the peculiarity of its constitution, it is capable of adapting itself to a wide range of circumstances, and hence the universality of its occurrence. We have two distinct forms, and, under constant conditions, permanent varieties, namely, the typical *A. avenaceum* in deep and moist soils, and the curious variety *bulbosum* in sandy lands. The former of these has a swelling at its lower node; but as in its locality there is always sufficient and regularly supplied sustenance and moisture, there is no need for the nodular growth assumed by the var. *bulbosum* when growing in sands, and provided as a storehouse of food for its living on in those periods of drought with which arid sands are mostly affected at some season or other.

These bulbs, which are the ordinary *nodes* of the grass much enlarged, look like a string of onions on a small scale, which has given rise to its popular name of *onion couch;* and upon the sand-beds upon which rest a great part of the towns of Gloucester and Cheltenham, and on the broken-down sandstone of the new red about Worcester, or the silicious drifts and soils of other districts, it sometimes forms a most troublesome weed, as each node is capable of growing a distinct plant, and so succulent are these that heat and dryness have even less chance of killing it than the common couch; the only way to get rid of it is to hand-pick it after repeated ploughing and harrowing.

It may be supposed that the var. *bulbosum* would be a useful grass on sands; but as its propensity is to increase by roots, and it sends up no second growth of culm, as does the *A. avenaceum*, its yield of herbage is not half that of the true species; its bulbous growth, however, is large and rapid, and its knotted onion-

like traces are much in the way of any crop with which it may be intermixed.

The very bitter taste of the nodular masses would almost point it out as of medicinal use, but we have never heard of its so employment.

CYNOSURUS—*panicle* spicate, flowers hidden in a comb-like shield,—*involucre* of botanists,—glumes equal awned, *glumel int.* with or without an awn.

Cynosurus cristatus—head of flowers forming a narrow spike, florets with a short awn.—P.

Cynosurus echinatus—head of flowers broadly ovate, florets with a rather long awn.—A.

The comb-like shield by which the *locustæ* of flowers are separated from each other in this genus is sufficient to distinguish it from all others.

Of our two British species only the first needs attention here, which we shall accord it, not so much because of the character of "a valuable grass" which Hooker gives it, perhaps following Sinclair, but in order to give our own independent observations upon a grass which is so abundant, and which, as we think, has been overmuch cultivated.

Probably much of the error which we conceive attaches to this species has arisen from the company in which it is usually found in its favourite upland localities, and hence such grasses as *Festuca ovina*, sheep's fescue, *F. duriuscula*, hard fescue, *Lolium perenne*, perennial rye-grass, and *Poa pratensis*, common meadow-grass, which in such places yield an unusually sweet herbage, have been robbed of much of that character which has been erroneously attributed to *Cynosurus*.

Sinclair says, "In some parts of Woburn Park this grass constitutes the principal part of the herbage on which the deer and Southdown sheep chiefly browse, while another part of the park, which consists chiefly of the *Agrostis vulgaris fascicularis*, Agrostis vulgaris tennifolia, Festuca ovina, Festuca duriuscula, &c., is seldom touched by them; but the Welsh breed of sheep almost constantly browse on these, and almost entirely neglect the Cynosurus cristatus, Lolium perenne, and Poa trivialis."

Now, in opposition to this, we beg to offer our observations, of some eight years, upon this grass, as it occurs in the park of Earl Bathurst at Cirencester.

This park, which is very extensive, rests on the stonebrash of the great oolite, with some of the higher ridges just capped with forest marble clay; all parts of this, and especially the portion called the Deer Park, is full of the *Cynosurus cristatus*, which grows equally well on the brash and the clay, and the thickness

of the grass may be estimated from the fact that scarcely six inches of space occurs without its occupants of one or more of the *dry sapless culms* of the C. cristatus. Now this park is *constantly* stocked with deer, Southdown sheep, horses, and oxen, by which the general turf is kept well cropped down, and yet no dead culms of any other grass will, as a rule, be found to prevail. Let it therefore be borne in mind that this is different from a meadow where the culms may become hard and woody before cattle are turned into it: they are always here, and keep every other grass from flowering but the one in question; it is therefore quite evident that here at least the *C. cristatus* is not a favourite with deer or Southdowns.

Perhaps, however, it was Sinclair's very observation of the quantity of culms in Woburn Park that led him to conclude that it formed so great a mass of the herbage; but if we bear in mind how very small and wiry these culms usually are, and how short in the leaf are the tufts of grass by which they are accompanied, we shall have reason to conclude that after all *C. cristatus* may there form but a small proportion of the herbage: at all events, we may safely determine that, if the grass in its young state was so favourite a pasture, it would, like others, be kept from growing culms by constant depasturing, but the grass in question seems all the more because even the young shoots are never cropped. From these observations we feel bound to conclude that the *C. cristatus* is both a poor hay and pasture grass, and neither in quantity nor quality of either worthy a place in a good meadow; and though it is true that it improves vastly under liberal treatment, yet the culms are left even in the lowlands on depasturing, and it fortunately happens that improvement of a pasture will cause the dying out of the greater portion of the grass in question, as it is essentially one of the poor pasture which cannot maintain its ground on the advance of other and more important species. The culms are gathered in quantity for straw-plaits, for which they are well adapted both from their fineness and strength of fibre.

*** *Spikelets (locustæ) with three or more perfect flowers.*
† *Spikelets forming bilateral spikes.*

HORDEUM—*florets* in threes, of which the central one is fertile, the lateral ones usually imperfect; *glumel* incorporated with the seed.

1. *H. sylvaticum*—wood lyme-grass—wood barley; spike smooth, upright; spikelets three-flowered; florets with a long awn; leaves flat and drooping.—P.

2. *H. murinum*—wall barley; spike about two inches long;

spikelets three-flowered; central perfect; lateral ones imperfect; all with long awns.—A.

3. *H. pratense*—meadow barley; spike smaller than in the preceding; lateral florets with short awns; central one with an awn twice the length.—P.

The first of these, *H. sylvaticum*, is usually named *Elymus Europœus*, but its position is perhaps more natural with the barley, though it would appear to have a greater affinity with the cereal than the meadow types of the genus. It is essentially a wood grass, with broad flat drooping leaves, but as yet we know nothing of its character in cultivation, but, having this year collected a lot of seed for our garden, we shall hope soon to be able to add some facts to its natural history.

As regards the *H. murinum*, this is confined to sandy soils, in which it is a sad weed, especially in corn-fields, banks, and hedge-rows—the tertiary sands of Suffolk, the marine sands in the old Severn strait, decomposed sandstones, and indeed a perfectly sandy soil anywhere is peculiarly liable to it: it is not strictly a grass of the meadow, choosing the margins of fields, edges of pathways, mounds, and hedge-banks. Its plentiful green herbage grows very early, and is not deficient in nutritive properties, so that it may be grown for soiling, but care should be taken not to let it advance to flowering, as the long rough serrated awns are most obnoxious to cattle, sticking about the mouth and causing great irritation; from this cause hay is much deteriorated by its presence, so that corners of fields in which it may occur should not be mown with the crop, but be cut earlier so as to prevent its seeding.

H. pratense—much smaller than the former and decidedly pastoral in its habits, growing in good grass-fields and especially such as are liable to inundations, and also occupying a place in irrigated meadows—its herbage is of good quality, and all kinds of cattle graze and do well where it is abundant; but though its awns are not so long or so stiff as those of the *H. murinum*, they are still highly objectionable in the hay crop.

The presence of this grass is a good indication of condition, as it always occurs to a greater or less extent in good meadows, but uniformly refuses to grow even in small quantity either on poor heath or sour undrained clays.

TRITICUM—*locustæ* flat, alternate on the sides of the central axis (*rachis*); glumes transverse; external glumel either pointed or awned.

The only species that need be here described are the following, which are distinguished from the rest of the genus by their creeping roots:—

Triticum repens—creeping wheat or couch grass; *glumes* ribbed; *locustæ* of from four to eight florets; the *glumels* mostly awned, leaves broad and flat; *rhizome* much creeping.—P.

T. junceum.—Rushy sea wheat-grass; *glumes* obtuse, with many ribs; *locustæ* of from four to five florets, without awns; leaves *involute* (folded); *rhizome* creeping.—P.

The first of these constitutes the detested couch of the farmer, and is a grass more catholic in its tastes and habits than almost any other; so much so indeed, that hedge-rows, road-sides, the pasture-field, and waste places, no less than arable lands, all upon every kind of soil, will be occupied by it to greater or less extent; and as lands in which it is allowed to increase are considered *par excellence* as "foul," the removal of couch is a matter in which all farmers are occupied and interested. Considering, therefore, the perpetual warfare that is waging against this grass, it is surprising how much of it still remains, even in some well-cultivated districts. Much of this may be accounted for in the unploughed spaces under hedges or stone walls, in which it seeds and thus forms a nursery for the fields; and besides, the *rhizomes* are cut off by the plough and become scattered by the operation of the harrow, and thus a centre is formed in the field, from which it spreads in like manner, so that a quantity of couch has always to be got rid of.

Much of the evils arising from this grass may be prevented by the timely use of the fork, which should always be brought into requisition upon every couch centre that may be detected, and that before ploughing for any and every crop, as this instrument is capable of following the plant in its depth as well as breadth, while the plough only cuts it off for the depth limited by its operations. This method, it is true, adds a little to the first expense of tillage, but it saves much after trouble, and is far cheaper in the end.

The same circumstance which renders the plant just described so great a pest to the farmer, namely, its creeping habit of growth, should impel us to preserve the *T. junceum*, as it is confined to sandy sea-shores, which its long, tough, and flexile rhizome assists in so matting together as to prevent the encroachment of the sea-water on the coast.

Brachypodium—*locustæ* cylindrical, on short *pedicles* alternate on the central axis; *glumes* unequal, transverse.

B. pinnatum—heath false brome-grass—*locustæ* of from eight to twelve smooth florets; *awns* half the length of the florets; spike and leaves upright.—P.

B. sylvaticum—slender false brome-grass—*locustæ* of from eight

to ten florets; florets hairy; *awn* longer than florets; *spike* drooping; *leaves* bent downwards.—P.

The habits of these two species are very different—the former preferring poor open heaths and down lands, particularly on limestone soils; the latter growing in hedgerows and beneath woods and shaded places. Agriculturally they are both of them useless; but the former is well worthy of study for its indication of soil and its condition.

The B. pinnatum will be found partially intermixed with the grass of most poor upland pastures on limestone, to which small isolated specimens it is confined under a constant system of depasturing; but if left wild or only occasionally stocked, it is astonishing how quickly the least bits spread into rounded patches, often of several yards in diameter, which, if cattle be turned into in the summer, they leave wholly untouched, and so it seeds, besides spreading by short rhizomes until the greater part of a pasture may be taken possession of by this useless and distasteful grass.

The best way to get it under is to fold sheep on a portion at a time, especially through the early spring, feeding them with corn, hay, and a few turnips; in which case the dead grass is trodden into manure, and the sheep manuring so encourages the growth of the sprinkling of better species, which before were thin and isolated, that the enemy is subdued in an incredibly short space of time; even one season being enough to destroy the greater portion, and reclaim a pasture that was before going fast to waste.

The B. pinnatum is also a great pest in hedgerows and on mounds, especially on the Cotteswolds, where it is a constant denizen. It should be carefully forked from the former, and before it has seeded, especially in the young state of the fence, as, from its upright and close method of growth, much injury results to the quick from being smothered, besides the exhausting powers which it possesses.

The B. sylvaticum is usually refused by all kinds of animals, but, from the readiness with which it grows under wood, it affords a tolerable covert for game.

LOLIUM—*glume* of one valve to the lateral (not transverse) *locustæ*, two to the terminal one; *glumels* sometimes awned.

Lolium perenne—perennial rye-grass—*locustæ* of from six to eight florets, awnless; leaves mostly upright, of a dark-green hue; of this there are several varieties.—P.

Lolium Italicum—*locustæ* of from six to eight awned florets; leaves broad drooping, of a light green colour.—B.

L. temulentum—*locustæ* equal in length with the glumes.—A.

The *L. perenne* in its usual form is found almost everywhere, but more especially in good pastures: brought under cultivation as "seeds," it is liable to a great number of variations, especially in size and in a disposition to a greater or less permanency of growth, and hence arise the many names which its varieties are known by in the seed-market. The properties of the true *L. perenne* are such as to render it very valuable to the farmer, as it soon arrives at maturity, yields a good weight to the rick, and in the meadow stands depasturing to any extent, yielding a perennial supply of good succulent leaves, which are readily eaten by stock of all kinds. In arable culture, however, its permanency is most uncertain, as it generally begins to die out, especially after the first hay crop; and this all the sooner and the more certain in proportion to the longer time the grass is left before being cut.

The *L. Italicum*, which is perhaps after all only a variety of the *L. perenne*, has been much recommended as a self-grass, and particularly for soiling: the reports of its yield under watering with sewage manure are almost fabulous; however, on limestone soils, and on light lands in general, it is now sown as a separate crop, in which case it comes in for pasture in the following spring, in which state it may be continued for one or two years according to circumstances, though it seems to be, strictly speaking, a biennial form.

These varieties of rye-grass are the only ones usually employed in seeds in this country, and they are either sown by themselves or in company with different trefoils, such as Trifolium pratense, T. medium, T. repens, Medicago lupulina, and others. The principal reasons for its preference, as stated by Sinclair, are the quantity of seed which it produces, the readiness with which this can be collected, and the facility with which it vegetates under circumstances of different management.

L. temulentum—drunken darnel—is an agrarian weed, now of comparative rarity, and fortunately so, if the following character of it be true: Sinclair says, "it has from the earliest ages borne the name of *drunken darnel*, and there can be no doubt of its deleterious qualities, whether in meat or drink." Parnell gives a modified opinion hereupon: he remarks, "the seeds, *it is said*, when eaten, produce vomiting, purging, violent colic, and death." Linnæus' opinion was, that the seeds, when mixed with bread, produced but little effect unless when eaten hot; but if malted with barley, the ale soon occasions intoxication. Sir J. E. Smith, in his 'English Flora,' says, "the seeds are of very evil report, for causing intoxication in men, beasts, and birds, and bringing on fatal convulsions." Haller mentions them "as

communicating these properties to beer." Vol. i. p. 175. Hooker and all botanists follow in the same strain, but merely quoting from each other, as none of them seem to have any personal knowledge of its qualities. Of late years it has been confined in its range, and so limited in quantity, that we have never been enabled to procure sufficient to follow out an investigation into this interesting matter; at present, however, we confess to the belief that its injurious qualities have been much overrated, if indeed the tales about it are not altogether fabulous.

Foreign seeds, flax more especially, are almost sure to yield a little of the plant on sowing.

†† *Flowers paniculate, flowers more or less lax.*

POA—*panicle* lax; *locustæ* of from five to ten florets; *glume* of unequal valves, the inner glumel notched at the extremity; part of the genus sometimes referred to *Glyceria.*

1. *Poa annua*—*locustæ* of about five florets, not webbed.—A.
2. *P. trivialis*—*locustæ* of about three acute webbed florets; leaves with a rough sheath, ligule pointed.—P.
3. *P. pratensis*—*locustæ* of about four acute flowers, with a web; culm and herbage smooth; ligule short and blunt; rhizome creeping.—P.
4. *P. compressa*—culms flat, oval on a transverse section, rhizome creeping.—P.
5. *P. nemoralis*—locustæ of three flowers, slightly webbed; ligule short; culms slightly compressed; rhizome indicated.—P.
6. *P. fluitans*—locustæ of from seven to eight florets obtuse, leaves broad and floating on the water.—P.

1. This grass is found about mud-banks, road-sides, ditches, and dirty places, a life for which its chemical analysis shows it to be well adapted, as, according to Mr. Way, it contains a large quantity of water and less ash, both in the dried and undried grass, than any other species upon which he operated; and upon this he remarks, that "the specimen of annual meadow grass, *Poa annua*, differs from all the others with which it is associated, both in the low percentage of silica and the corresponding decrease in the proportion of potash, which, whether calculated on the natural or dry specimen, is peculiarly low;" and to this is appended the following note, "Annual meadow grass is said (see Lowe's 'Agriculture') to be the most productive of all the grasses: Is this in any degree to be attributed to its more moderate mineral requirements?" In an agricultural point of view, this grass may be considered as a weed, as it has scarcely any feeding

properties, and though it sometimes presents an apparently green turf over alluvial flats, and anywhere with a muddy subsoil, such grass affords, as the farmers say, "no heart"—"no proof" in it. On some land of Lord de Mauley's celebrated for scouring cattle, this grass was a prevailing one. It is a great pest in garden-walks, increasing rapidly where allowed to seed. Salt has been recommended for the prevention of its growth, which it does for a time, but requires a constant renewal of the dressing to quite keep it under.

2. *Poa trivialis*—rough-stalked meadow grass.—This species is mostly confined to low and damp situations, often forming a great part of the bulk of hay in river-side meadows, but growing in the greatest abundance in irrigated pastures, especially in such parts as though not stagnant are always moist. Under the most perfect irrigation-system, it is by no means abundant. As an upland grass it is never met with in nature, and if employed in a mixture for such situations it usually disappears in a few years. In its favourite habitat it yields a large bulk of hay, but is usually very late in its growth, and this is followed by a good bite of aftermath; but our observations confirm us in the opinion that it is very watery in its composition, and its herbage is by no means of the sweet quality that belongs to the best species. Sinclair, however, speaks very highly of its properties, and in this he is followed by Parnell; he says, "the superior produce of this *Poa* over many other species,* its highly nutritive qualities, seasons in which it arrives at perfection, and the marked partiality which horses, oxen, and sheep have for it, are merits which distinguish it as one of the most valuable of those grasses which affect rich soil and sheltered situations."—*Hort. Gram. Woburn.*, p. 88.

Now, we cannot say that we have observed any partiality of cattle for this grass, and feel inclined to the belief that the following circumstances have contributed not a little to an over-estimation of its qualities in this respect. If we examine its progress we shall find that it is nearly a month later than the general mass of the meadow grasses; so that it is no wonder that cattle should choose the green leaves of this species at a time when its congeners are in culm; but this is no argument for its superior value; on the contrary, we are constantly being told, in the language of the farmer, that hay from such situations has not the "proof" in it of that of the good sound meadow—a circumstance which may, no doubt, in part be attributed to the quantity of water it contains, as shown by Mr. Way in his 'Fourth Report on the Analysis of the Ashes of Plants,' to which we have been

* Here he does not mean of Poa, but other species of grasses.

greatly indebted for some valuable information, and from which we extract the following table, showing the percentage of water in three species of Poa compared with *Phleum pratense.*

Grass.	Date of Collection.	Water per Cent.	Nature of soil.
Poa annua	May 28 ..	79·14	Loam, with gravelly subsoil.
,, *pratensis*	June 11 ..	67·14	Dry calcareous loam.
,, *trivialis*	June 18 ..	73·60	Calcareous loam.
Phleum pratensis ..	July 11 ..	57·21	Ditto.

From this, no less than long observations of its history and general characteristics, we should feel disposed to rank *Poa trivialis* as a very inferior grass to *Poa pratensis,* holding indeed, as far as the value of its hay and herbage is concerned, an intermediate position between the latter and *Poa annua.* As a weed, the *Poa trivialis* is often exceedingly annoying, especially on poor damp clays. We have seen it in some of the stretches of the Fuller's-earth, choking even the scanty crop of grain which this stratum will grow when ill drained or otherwise unmitigated; it is however easily got rid of by thorough-draining, and letting light and air into this stubborn soil.

3. *Poa pratensis*—smooth-stalked meadow grass—is very constant in pastures, and especially in those of the best quality; it yields a good bulk for the rick, and sends up a quantity of herbage for the aftermath, which is less injured by cold and other climatal changes than almost any other species; its range is very wide, being found on dry uplands, in deep loams, and in both flooded and irrigated meadows, and should always be largely intermixed with seeds in the laying down of permanent pasture. Thus it will be seen that our experience of this species is quite at variance with that of the 'Hortus Gramineus Woburnensis,' in which it is stated, that "upon the whole it is an inferior grass; its strong creeping roots exhaust the soil; its growth after mowing is slow; and its spring growth, though early, is inconsiderable; and upon the whole it is unfit to be introduced among the superior sorts."

Now, as regards the creeping roots, these are never strong in the pasture; if, however, the grass be employed in turf-walks in the garden, it then spreads strong rhizomes into the plots in contact, on which account it should never be brought to such situations; but how rhizomes could exhaust the soil except by producing grass, we cannot make out; the truth is, that all good grasses exhaust the soil if taken off in the shape of hay, and this one especially by reason of its good crops; but such should be

invigorated by manuring and good cultivation, for which this species amply repays.

4. *Poa compressa*—flat-stalked meadow grass—can only be looked upon as a weed, and its thin wiry rhizomes make it very troublesome in some of the brashes of the inferior and great oolite limestone rocks; the Gloucestershire farmer distinguishes it by the name of squitch, whilst the stronger rhizomes of *Triticum repens* are termed couch. This weed is very difficult to get rid of, as it creeps beneath the stones, so that the plough has but little chance with it, and where it once takes root it is too rapid in its spread to be mastered by the fork. The plan we have seen as most effective is to sow white mustard in the wheat stubbles in which it prevails, and, when eaten off by the sheep, apply a dressing of decomposed farmyard manure, and plough up for a winter fallow. In spring prepare for the turnip crop, which should be sown on the ridge; by such means the soil becomes deeper and better in quality—two circumstances which, besides want of rest, are highly prejudicial to the growth of squitch.

5. *Poa nemoralis* — wood meadow-grass — though early, yet yields so small a quantity of light culms and delicate leaves as to render it scarcely worth cultivation; at the same time, if cut early it sends up a second crop of flowers; and its habits point it out as well adapted for glades in parks, and under trees. Its herbage, though not of great amount, is of good quality, and we have observed that cattle eat it greedily.

6. *Poa fluitans*—floating meadow-grass. In this species we have a form at first sight so distinct from Poa as almost to entitle it to another generic name, which indeed by some botanists has been given, in that of *Glyceria*, a separation which we should at once adopt, both from its structure and habit, were this the only species in the group; but its congeners, *P. maritima*, *P. distans*, and *P. procumbens*, sufficiently unite it to the true Poas for all practical purposes. This grass, with its evergreen leaves, will be constantly found floating on the water of the pool or the stream; in the summer it sends up some upright culms, which are more or less branched, and, with the whole herbage, very sweet in flavour, on which account cattle prefer it when young to almost any other species; it is, however, remarkably liable to become ergotised—a circumstance which would appear to render it highly injurious to cattle which are obliged to partake of it, arising either from the ill effects of the ergot itself, or the damp circumstances under which the grass grows, or perhaps both causes combined. In some cases which have come before us, abortion in cows has been frequent in low meadows traversed by

watercourses and wet stretches in which this grass has been abundant.

BRIZA—*panicle* lax; *locustæ* of from six to eight very tumid florets; *glumes* equal, rounded, and with the whole flower quite smooth.

Briza media—quaking-grass—is so called from the restlessness of its pendulous flowers, which are comparatively heavy, and balanced on delicate rounded *pedicels.* Though a beautiful species, it is of no use agriculturally; however, as it grows for the most part in poor, stiff, undrained clays, it may always serve by its presence or absence as an indication of condition. If present in quantity, we may predicate a stiff unmitigated clay, such as are found in the lias shales, Oxford clay, forest marble, and London clays, and especially where not visited by local deposits, undrained, or otherwise badly cultivated; these formations will be found to afford too much of this species, and far too little of those of a better quality. If, however, the soil be merely wet, and not of a decidedly stiff description, less of the quaking-grass will occur, but the specimens will be far larger in size, and equally useless as food.

This grass is not touched by cattle, and, therefore, its culms may be observed late in the season, usually accompanied by those of the Cynosurus cristatus. At any time it yields little to even the scanty bulk of the hay from its favourite habitats, and its short leaves render it useless for pasture.

DACTYLIS—*panicle* with the primary branches long; pedicels short, so that the flowers are clustered in bunches; *glume* of two unequal valves arranged obliquely; *glumel* pointed, almost awned.—P.

Dactylis glomerata is too well known to need further description, especially as we have but a single native species to consider; its agricultural capabilities render it an important one to the farmer, as it yields a very large bulk both of culms and long leaves to the hay crop, and a no less proportion of aftermath; and though somewhat rough, coarse, and woody in its culms, especially if left too long before cutting, yet it presents for the most part a highly nutritious and bountiful supply to the rick; it is, moreover, remarkable for its quickness of growth after mowing, as in a few days its light-green succulent leaves will be seen considerably overtopping the surrounding turf; and if at this time cattle be turned into the field, they invariably make a first attack upon the young cocksfoot.

Sinclair, in speaking of this grass, says, "By various tests to which the leaves and stems were submitted at different periods

of their growth, the author found that the stems, when full grown, contain more nutriment than the leaves at any time;" and his general conclusions respecting this grass are, that "it is more valuable for pasture than for hay, and, for the latter purpose, is superior to rye-grass and many others." "If constantly kept closely grazed, it yields a greater profit than used in any other way, merely because the leaves grow rapidly, and give a full bite." This, though appearing at first as somewhat paradoxical, is quite in accordance with our own observations, which lead us to conclude that, in all its stages, this is a highly valuable grass. This view, again, is confirmed by Mr. Way's analysis, which determine it to belong to the best agricultural species. It has the merit of growing in almost any soil, and enduring a great range of climatal difference; it attains to maturity, or at least to as great a bulk as any other species, comparatively soon, and is, therefore, good for admixture in the laying down of permanent pasture, and might, we think, be profitably employed in a mixture with rye-grass in seeds. Its more robust and faster growth than most other species should prevent its being used for lawns; and the admirers of cricket should take care to have it expunged from their field—a consummation indeed which will soon result, even when present, from plenty of practice of the 'noble sport.'

There is a variety in the seed-market known as giant cocksfoot; it is not different from the usual grass when in cultivation, which indeed sometimes attains gigantic proportions.

FESTUCA—*panicle* lax; *glumes* unequal; finely pointed outer *glumel*, with a short *awn* or bristle at the summit.

In this genus, so far as the farmer is concerned, we have two types which may be conveniently tabulated as follows:—

a. *Leaves more or less setaceous* (*hairlike*).

1. *Festuca ovina*—sheep's fescue—leaves setaceous; panicle diffuse; rhizome absent.—P.

   Festuca ovina, var. duriuscula—hard fescue—leaves nearly plane on the culm, those of the root inclining to setaceous; rhizome absent.—P.

   Festuca ovina, var. rubra—creeping fescue—leaves involute (rolled inwards at the edges), thus often appearing setaceous; panicle inclining to one side; rhizome more or less creeping.—P.

b. *Leaves plane.*

2. *Festuca loliacea*—spiked fescue—panicle spiked in two rows, like Lolium perenne; leaves long, broad, and drooping.—P.

Festuca loliacea, var. pratensis—meadow fescue—panicle diffuse, inclining to one side; leaves upright and succulent. —P.

Festuca loliacea, var. elatior—tall fescue—panicle large; much branched; leaves harsh and rigid.—P.

On comparing our nomenclature with that of botanical authors, it will be seen that it differs materially from all of them; our reasons for this course will be made apparent from the following observations and experiments:—

Six years since we sowed separate plots of the three first forms with seed from the Messrs. Gibbs; these came up well, and soon established themselves in the separate tuft method so peculiar to this group when unmixed with other species. The first two years they were tolerably distinct, now, however, the following facts are observable:—*F. ovina*, *duriuscula*, and *rubra*, scarcely distinguishable in size or details, while the creeping habit of root of the latter is entirely lost. It may be remarked that the *F. rubra* is not amongst our wild forms at Cirencester, but we have occasionally met with specimens of *F. duriuscula* in the road-dirt with which the tops of our stone walls are frequently capped, having a decidedly creeping habit, which, if shown as a tendency in the "light sandy pastures near the sea," which is given by Hooker as the habitat of the *F. rubra*, may account for ovina taking on the rubra form in such a locality.

As respects *ovina* and *duriuscula*, it may be remarked that poor uplands present the first, the bushes and hedgerows of these the second, which is sure to prevail in good upland meadows; but seldom are they greatly intermixed, which perhaps may be taken as an argument that the variety is induced by the difference of circumstances. From long observation of these, we can only consider them as varieties of the same species, and had we choice of names should choose for it *F. duriuscula*, as the departure seems to be from that type, of which the *ovina* is the mountain form and *rubra* a sea-side one.

Festuca loliacea varieties.—At the same time as the above, were sown the three forms tabulated below in the following order:—

Festuca loliacea.	Festuca loliacea, var. pratensis.	Festuca loliacea, var. elatior.
Plot 1.	2.	3

These plots the first year of flowering presented the following appearances:—

Plot 1. *F. loliacea*—most of the plants were of the true spicate

type, but were sparingly intermixed with paniculate flowers; the herbage of all was of the rich green which characterises the true type.

Plot 2. *F. loliacea, var. pratensis*—all came true, but with a tendency to a rigidity of leaf.

Plot 3. *F. loliacea, var. elatior*—scarcely distinguishable from plot 2.

In three years great changes had been wrought, as under:—

Plot 1. No spicate flowers in the whole plot.

„ 2. More rigid and larger; in fact, none of the true type.

„ 3. A little larger, but otherwise not distinguishable from plot 2.

Now in the sixth year the *F. elatior* form prevails in all the plots. Here, then, we think that it is satisfactorily proved that these three forms are all referrable to a single species, as the change has taken place, not by hybridisation, but in individuals; at the same time they may maintain their distinctive characters under the following circumstances:—

1. In meadows by the side of rivers, especially where subjected to occasional floods—as the Isis at Oxford, or irrigated meadows on the banks of the Churn at Cirencester. The *F. loliacea* is constant, and is a most valuable grass for hay or pasture.

2. In rich meadow flats, as in the vale of Berkeley, the celebrated locality for the production of double Gloucester cheese, the *F. loliacea, var. pratensis*, is a common and valuable denizen, and any meadow where it maintains its characteristics may be considered as good in quality.

3. On the alluvial sandy clay banks by the seaside, or poor silicious clays inland, the variety *elatior* rears its tall coarse form. In the county of Gloucester the warp mud on the banks of the Severn estuary is always occupied by this grass, which we look upon only as the extension of the *pratensis* from the rich flats within the sea-wall boundary.

The *F. pratensis* is a grass which is always recommended for admixture in forming new pastures, on which account there can be but little doubt that it was used in the glades laid down within the last few years at the entrance of Oakly Park, the seat of the Earl Bathurst. When first sown it came up true enough, though with a disposition to harshness; the last three years it has become *elatior* in all its features, and is now in such large coarse *tussacs*, or *hassocks* as they are technically called, as to make the spot dissightly as a lawn and much impaired for hay or pasture. The secret here appears to be that the soil consists of sandy clays of the Forest marble rock, the texture of which is very similar to that in the favourite habitats of this form of grass.

Here, then, we see in these forms of fescue, plants which assume what have been taken as specific differences, not only from change of circumstance giving rise to varieties which are maintained from seed, but assuming a varied form from the same seed, and absolutely becoming *pratensis*, and afterwards *elatior*, from a typical form of loliacea; and so certain has this been the result in our own experimental garden, that the result of twice sowing the three forms of seed from different seedsmen has been the negative of *loliacea* and *pratensis* and the permanent establishment of *elatior* on all the plots.

As therefore *F. elatior* seems to be the more perfect state of the grass, this name should more properly be attached to the group.

In an agricultural point of view, the fescues afford widely useful varieties, each of which is valuable under certain distinct circumstances, and, indeed, under them keep their typical forms, thus:—

F. ovina is essentially a grass of the thin soils resting on rocky uplands, as on the mountain limestone, the oolites of the stony Cotteswolds, and most mountain ranges.

F., *var. duriuscula*—in the valleys between such hills, and in the more sheltered pastures in upland districts.

F., *var. rubra*—in sandy loams of the lowland meadow, and by the sea-shore.

F. loliacea—rich meadows, on river-banks, or under irrigation.

F., *var. pratensis*—best lowland pastures not liable to floods.

F., *var. elatior*—on sandy clays, or other stiff or strong land, especially on warped sea-shores.

In each of these situations the peculiar form is well adapted for yielding, under the circumstances, as good a crop and of as good quality as any other species. There can be no objection to their encouragement in the habitats indicated. The last, however, is exceedingly coarse, and would thus only be adapted for the grazing of such cattle as may occasionally be enabled to rough it.

BROMUS—*panicle* lax; *glumes* more or less tumid; outer *glumel* with a long awn from near its middle, inner one *ciliated*, edged with fine hairs.

Of this genus there are several species which are of little moment to the farmer; and indeed those in which he is interested are, for the most part, rather enemies than friends. Of these the following may serve as a synopsis:—

a. *Annual.*

1. *Bromus mollis*—soft brome, "lop" of the farmer—*locustæ*

ovate, of from six to ten florets, upright, on short pedicles; flowers and whole plant hairy.

2. *B. mollis, var. racemosus* — smooth brome—the same as the preceding, only that the flowers are smooth and glistening.
3. *B. mollis, var. commutatus*—field brome—locustæ of from ten to twelve smooth florets, more or less drooping, upon long and slender pedicles.
4. *B. secalinus*—locustæ of from eight to ten florets, which are usually smooth, but in the sub-variety *velutinus* are hairy; much drooping in seed, when the florets are more distinct and separated than in the other forms.

b. *Perennial.*

5. *B. erectus—locustæ* upright, on short pedicles; florets lanceolate, smooth; anthers bright orange.

The two first of these may practically be taken together, as the *racemosus* can only be considered as a smooth form of *mollis*, and by which the latter is but sparingly accompanied, being produced from the same sample of seed. It is known by the farmer under the name of "*lop*," and is a detestable weed, especially in seeds, where it sometimes prevails to such an extent as to form the greater part of the hay-crop. In this case it is difficult of eradication, because it is much earlier than the rest of the grass; and if the hay be cut early, to prevent its seeding, there are always some unflowered stems left behind, which will shoot up and seed in the aftercrop. On this account it has been recommended to be cut often, but, after all, this is a method of cure which would frequently render a crop of seeds of comparatively little use to the farmer. "Prevention, therefore," says Sinclair, "is most to be recommended," and this is to be achieved by judicious cropping and liberal treatment, and more especially as this grass is mostly a denizen of poor exhausted soils. But, above all, we should be particular not to sow this grass with our crop—a process by which its continuance is constantly ensured without proper care, and which results in the following manner.

A dishonest farmer has a crop of seeds which may be very foul, especially with a prevalence of lop. In this case he knows it will be not only a short but a poor crop of hay and grass; he therefore seeds it, and the lop and the rye-grass thus become inseparable, and the superior weight of the former makes up a tolerable weight of seed, which, even if sold at a reduced price because it is not of the best quality, pays better than by any other mode of dealing with it; and thus, as long as men are rogues enough to seed foul patches, and others are so foolish as

to buy the cheapened produce, so long will this be a source of weeds. Yet, so far as clean farming is concerned, we cannot consider any as entitled to that name unless as well as destroying weeds it also provides against sowing them. "Prevention" is indeed better than cure, as weeding, however judiciously performed, is sure to leave enough of prolific enemies to continue the pest, so that it is the best, and safest, and, we think, the cheapest cure. We have been thus hard upon the lop, as it can only be considered a weed, being an annual grass; and, notwithstanding the high position in which my friend Dr. Voelcker has placed it in Chemistry of Food, in respect to its feeding properties, which places it amongst grasses of superior quality, yet cattle will not eat it if they can possibly avoid doing so, and hay is always poor in which it occurs, which is not to be wondered at when the lop, for the most part, elects to grow in the most impoverished soils.

Bromus commutatus we can only view as a variety of *B. mollis.* Its situation is that of low damp irrigated meadows, in which the *mollis* is quite exceptional, though, when it does occur, it assumes the drooping habit of the *commutatus*, and offers many intermediate states. Now, as we have watched the laying out of poor pastures as irrigated meadows, we have observed that two or three years is often capable of changing the *B. mollis*, which was before alone, into *commutatus*. Of course it may be considered that this was in virtue of that law of substitution of one species for another which universally occurs on a change of soil, but we incline to think that much of this where it occurs is due not merely to this cause, but to real change of form, as the result of an alteration of condition and circumstance; and, as regards the grass under consideration, our chain of evidence is nearly complete in establishing this position, when it is stated that the *B. commutatus*, from the irrigated meadows, most certainly in cultivation in my experimental garden, has resulted in some fine examples of *B. seculinus*, a form not before known there, and therefore not liable to have led me into error, as might be the case where the different varieties are wild natives.

That *B. arvensis*, and perhaps other forms, may by cultivation be shown to be varieties of an annual grass, of which *B. mollis* is the common type, is an idea which seems to be countenanced by the protean forms of *mollis* and its congeners.

B. erectus is a perennial brome, very partial to limestone soils, and is one of the commonest grasses on the poor thin oolite brashes, extending along the whole of the Cotteswold chain of hills, from Bath to Chipping Campden; it is no less prevalent on the chalk range, and the quantity of lime which its ash contains may have something to do with this preference. The per-

centage of this product (lime) in B. erectus, when compared with some other species, is interesting: we therefore copy it from Mr. Way's fourth Report on the Analyses of the Ashes of Plants:—

	Percentage of Lime in Ash.
Festuca duriuscula (a common chalk species).. ..	10·31
Bromus erectus (upright brome)	10·38
Dactylis glomerata (cocksfoot)..	5·82
Alopecurus pratensis (meadow foxtail)	3·90

Indeed, as regards lime, out of sixteen species the B. erectus is only exceeded by the following:—

	Percentage of Lime.
Poa annua (annual meadow)	11·69
Phleum pratense (Timothy grass)	14·94

—the first of these always succeeding best on road-scrapings from limestone road-metal, as Bristol limestone, and the latter on alluvial mud-banks from rivers, which is always full of shells. These are facts which, while they show the general correctness of Mr. Way's analyses, at the same time point out their value and importance.

The B. erectus is usually refused by cattle; it is a tall grass, but from growing few culms and long leaves it appears much more productive than it really is. Whatever tends to the improvement of the pasture contributes to its disappearance, and its presence in quantity may be held as a sure sign of poverty of soil, as well as an evidence of its calcareous nature.

AVENA—*panicle* more or less lax; *glumes* thin and membranaceous; *glumels* pointed, adherent to the seed.

In this genus we have two divisions, one of which contains strictly agrarian species, which are doubtful natives, and are perhaps only derived from degenerated corn-oats. The other contains very distinct plants, exclusively belonging to the meadow.

a. *Agrarian Oats.*

1. *Avena fatua*—wild-oat—*locustæ* of three florets; *glumels* hairy all over, outer one with a long stout awn bent at right angles, and the lower half twisted when ripe.—A.
2. *A. strigosa*—bristle-pointed oat—*locustæ* of two perfect flowers; *glumels* with two long bristly points awned.—A.

b. *Meadow Oats.*

3. *A. pratensis*—*locustæ* of from three to five florets; leaves not hairy, finely serrated; whole plant rigid.
4. *A. pubescens*—*locustæ* of three florets; outer glumel jagged; leaves flat, more or less downy; plant soft and hairy.

5. *A. florescens*—locustæ of three florets, flowers small, yellow, very numerous.

Avena fatua is a grass which almost universally accompanies agrarian circumstances, that is to say, it seldom if ever occurs in a truly wild aboriginal state, but is an attendant upon tillage, and in some soils is a most common and detested weed in various crops, but more especially amid grain, whether of wheat, barley, or oats; sometimes too with beans or seeding vetches, or indeed in any crop which is of sufficient duration to allow it to ripen, and from which it is not eradicated in weeding by the hoe.

It is a tall grass, rivalling the height of the finest cultivated oat, from some forms of which, and especially those with a lax panicle, it is at a first glance not readily distinguishable; however, a more careful examination and comparison with the so-called *Avena sativa* enables us to make out the following differences:—

Avena fatua—Wild Oat.	*Avena sativa*—Cultivated Oat.
Florets usually three, each armed with a stiff awn, which is bent in the middle, the lower part twisted when ripe; covered, more particularly at the base, with straight harsh bristles; seed small and worthless.	Florets usually two, either with or without awns, but straight and less rigid when present than in A. fatua; quite smooth externally, and somewhat tumid from its enlarged seed or grain for which the plant is cultivated.

The experiments about to be detailed were performed with the *Avena fatua.* In the autumn of 1851 we collected some seed of the wild oat, putting it aside for spring planting, and in the spring of 1852 we drilled a plot of 2¼ yards square with the seed that had been kept during the winter—a fact to be carefully noted, as it forms a first and most important link in our chain of evidence, thus constituting what we shall hereafter revert to as a *cultivative process.* The seed came up well, the plants on ripening were tall and robust, and the grains presented a scarcely appreciable difference from the wild examples, but if anything there might have been a slight tendency to increase in the quantity of flour. The seeds again collected and preserved through the winter were sown in a patch of similar size in a different part of the garden in the spring of the following years 1853-54-55, with little alteration from year to year, though in some examples the following tendencies seemed from the first to be gaining strength:—

1. A gradual decrease in the quantity of hairs on the florets.
2. A more tumid grain, in which the covering "skin" was less coarse and the awn less stout and straighter.
3. A gradually increased development of kernel or flour.

The seeds of 1855, without selection, were treated through the

winter the same as before, and sown in the spring of the present year, the resulting crop, gathered in the latter end of August, presenting the following curious variations:—

	Proportion of each.
1st. Avena fatua, wild oat of the true type, with large loose panicles of flowers, thin hairy florets, with the bent awn twisted at the base	5
2nd. Avena fatua, var. sativa, with loose panicles of flowers, florets quite smooth and tumid, with or without *straight* awns, some few examples slightly hairy towards the base. This is near the potato-oat type	6
3rd. Avena fatua, var. sativa. Panicles more compact, flowers inclining to one side, grains more tumid than 2, quite devoid of hairs, awn straight. These present the type of the white Tartarian oat	12

Each of these forms is now separately saved for further experiment, whilst the shed seeds of the plot are left to grow as they would do in nature, with the view of demonstrating the downward progress by the reverse methods to those adopted in the cultivative ones.

We may add here, that in the article *Avena* in Morton's 'Cyclopædia of Agriculture,' Dr. Lindley referred to the probability of the wild origin thus demonstrated, suggesting that the cultivated oat is "a domesticated variety of some wild species, and may be not improbably referred to *Avena strigosa*, the bristle-pointed oat, which would become the common oat by a slight alteration of the form and division of its pales and the loss of one of its awns—changes much less considerable than are known to have taken place in other cultivated plants."

The experiments, as far as they have now gone, show us in the clearest possible manner that the *Avena fatua* is the parent of our cultivated oat, and that not only of one but of more forms or varieties produced in the same space of time and by the same series of operations,—conclusions which cannot be other than interesting to the botanist, whilst to the farmer they offer considerations no less curious in theory than important in a practical point of view.

If we can produce the cultivated from the wild weed oat, it follows that the weed may result from a degeneracy of the cultivated form; and this will serve to show how true the instincts of the old-fashioned farmer not unfrequently were, as we remember that some years since a main objection to the growth of oats on stiff lias clays was, that they left behind them wild oats; and all who have had to deal with them as a weed, as not unfrequently occurs on the stiffer lands of the lias, Forest marble or Oxford clays, may well dread any cause of its increase. As a botanical notion

this was never well received, but viewed as impossible by the species-maker; however, actual experiment has at length demonstrated its truth, and it may just be mentioned that a confirmation of this has in the mean time been arrived at by a different process, which we can now only shortly detail.

On the examination of stray plants of oats from shed seeds, where the year before oats had been the crop, examples are not uncommon with a few hairs at the base of the floret, whilst the awn will be mostly stiffer than those in the crop; and this on thin soils, where wild oat is not usual as a weed. Again on stiff clays, in which the weed prevails, many intermediate forms or degrees of wildness will be observable, perhaps derivable from the cultivated oats brought to the soil in manures.

But further, if we examine oats grown on good oat-lands, we are aware of the following characteristics—a greater weight to the bushel, and a more plump grain with a finer coat and the awns scarcely more than bristles; and, as we know from observation, these qualities are immediately reversed if we sow good oats from a favourable oat-soil in a district unfavourable to the growth of this corn.

Here, then, the result of our experiments and observations is to show that the wild oat by cultivation will yield different sorts of a cultivated or crop oat; so that new varieties, and that direct from the original source, are easily attainable; and also that the cultivated oat may degenerate into the wild form from which it has sprung, and in some soils in a very short space of time.*

A. strigosa, like *fatua*, is in all probability derived from some cultivated form, or, as Professor Lindley has hinted, it may be the wild form from which some cultivated examples have been derived; it is only found as an agrarian, and that very rarely, being more common in Scotland than in England, its place with us being supplied by the *A. fatua*.

Avena pratensis, in the stiff untractable land in which it delights to grow, can only be considered as a pasture weed, which, however, can soon be got rid of by draining and better cultivation; in short, whatever tends to the amelioration of the soil will quickly cause it to die out. It is too harsh to be eaten by cattle, so that it is fortunate that it is seldom to be met with in large quantities, being by far the rarer form of the meadow species.

A. pubescens.—Besides its general pubescence, this is well distinguished from the preceding by its very short upper leaves, which, when compared with A. pratensis, may be estimated as follows:—

* In this Report several curious botanical changes which took place as the experiment progressed have not been noticed, as they would unnecessarily burden the subject for the general reader.

	Proportions of Leaf-blade.	Proportions of Sheath.	Proportions of Leaves of base.
Avena pubescens	1	20	10
„ pratensis..	10	25	40

Its habitat is that of light upland pasture, in which it often forms a conspicuous feature, affording, however, but a small weight to the crop from the exceeding lightness of the culms and flowers, and its short after-leaves produce but little to the pasturage; it is, however, a sweet grass in all its stages, and one which is well kept down by depasturing at all seasons. A small proportion in laying down permanent pasture in the upland meadow will hence be not without advantage.

A. flavescens is, for the most part, a denizen of calcareous soils, on which it thrives remarkably well, being, though small, equal in point of produce to most other grasses by which it is surrounded, arising from the weak growth of some commoner and larger species on thin brashes. On this account it is a grass of great importance for admixture in light upland or limestone pastures, as it affords some sweet hay and no less good herbage for grazing—a circumstance which, as Sinclair justly remarks, recommends it to form part of even richer meadows, "and more especially if the land be elevated and without good shelter, as it thrives better under such circumstances than any other;" and animals are very fond of it.

PHRAGMITES—*Panicle* more or less compact; *glumes* and *glumels* finely pointed, the latter very unequal.

Phragmites communis (*Arundo phragmites*)—common reed—is too well known to need description; it grows in abundance on the margins of rivers and pools, and is made available for thatching purposes. In hedgerows and damp places, on clay soil, it will often be found on badly managed parts of the farm, where its great size and stout rhizomes make it a troublesome weed. Draining, however, is an effectual remedy, to which end this and kindred species are often useful, as directing attention to the state of affairs, not only as regards broad extent but in isolated patches.

XIX.—*On the different Mechanical Modes of Deepening the Staple Soil, in order to give it the full benefit of Atmospheric Influence.* By PETER LOVE, late of Manor Farm, Naseby, Northamptonshire.

WE conceive that the best way to write on any practical subject, is to follow the track of our own experience upon it as nearly as possible, without taking up too much time in laying such experience before our readers. We may first state that we have been extra-deep cultivators for upwards of thirty years, and our experience, in actually carrying out the plan, has extended over England, Scotland, and Ireland, upon many hundred acres of which the soil and difference of climate were very considerable.

We will begin by speaking of the effects of deep ploughing in autumn. But first we must solve the question what is deep ploughing? We have always laid it down as a rule, that ploughing land one-third deeper than had been the practice of the former cultivators is deep ploughing, and this rule we act upon every time the land is in roots, or fallow, until a foot is gained (which we have found the maximum desirable); it will be found that, where the four-field rotation and shallow cultivation is practised (as in the wolds of Yorkshire), where four inches is the general maximum depth, twenty years will have elapsed by the time a farm has been got to the depth of staple stated. We are quite satisfied that it is only for the root, or fallow crops, and oats, that deep ploughing is advantageous; we have ever found that for wheat, barley, beans, and peas, shallow ploughing produces both greater quantity and better quality of grain. We have always found that the earlier deep ploughing is done the better, and therefore have set the grubber to work as soon as the corn was off the land; indeed, in showery harvests we have frequently gone to work between the rows of shocks or stooks, so that the twitch and other weeds should be first cleared from the land, after which we ploughed the land from nine to twelve inches deep, with three horses going abreast; four, two-and-two abreast; or six, three-and-three abreast, with in every case the draught equalized, without which the deep ploughing of real stiff clay is almost insurmountable, because the power of making every horse draw exactly the same is (we must say), from long experience, indispensable to the comfortable accomplishment of this heavy operation, where a number of horses must be employed; indeed we often wished we could as easily deal with our men. Although it may almost appear superfluous to many of those who have so long seen our equalizing swingletrees at work, we will present

our readers with a drawing of them which may be the means of simplifying the way to those who have been in times past mere scratchers rather than cultivators of the earth. (See figures and description at the end of this essay.)

Our system of ploughing has been generally much laughed at, but we have found it the best for accomplishing the end we had in view, viz. exposing the greatest surface to the action of air, light, and frost; therefore we even now dare to put it forward in this essay, for the consideration of others, who have by experience found the advantages of exposing the greatest possible surface to the free action of the atmospheric changes. In order to attain this object, we have found it best to use a plough, long in the breast of the turnfurrow, or wrest, but short after passing the vertical part, so that it may leave the furrow only half turned, that is standing on edge, leaving an open space between each furrow slice, equal to the difference betwixt the width and depth of the furrow. This space leaves three sides of the slice to the action of the weather, while all the seeds of weeds, &c., that have been shed on the surface are under the influence of the air. In a warm well-sheltered valley, where vegetation is encouraged thus, by the time the first spring stirring takes place the plants from such seed have all vegetated ready for easy destruction; and from the pulverizing influence of atmospheric changes, the soil is well prepared to part with any root-weeds that may still be left there, and which, by the use of a good grubber or cultivator, are raised to the surface. The thorough amalgamation of the soil takes place when the land is dry; we might leave out this remark here, as we believe no member of the Royal Agricultural Society would attempt such an operation while the land was wet. We have found that, in the great majority of seasons, the earlier after harvest our deep ploughing was done the better, although we have obtained some good results from deep ploughing in spring; it is proper to mention here, that we have seldom successfully cultivated deep for anything but root-crops, fallow, and oats, seldom, we may say never, ploughing a second time for these crops, all the subsequent amalgamation and pulverizing of the soil being done with the grubber, harrow, and roller; thus the land is prepared without evaporating the moisture, so much required to hasten the vegetation and growth of the seed into a well-developed plant, that can bear the tortures of the fly, &c., under the influence of a scorching sun.

We ought to state, that in certain seasons strong clay is got into a much better state by deep ploughing in spring than in autumn; but as these seasons have always been great exceptions where we have lived, we have not practised the system generally,

although in 1840 we ploughed up stiff clay early in March, when it got thoroughly dried by sun and wind, then by genial showers got well damped through, and while so was well worked with the grubber, &c., which got it into a much better state for a crop than by autumn cultivation: the difference was just this—the soil in the spring cultivation is reduced into small clods, that are not liable to run again into one another and to form a plastic mass when a heavy glut of wet falls; as the interstices are more permeable to air, moisture, and heat, the aëration goes on more freely, while the atoms of soil are sufficiently small to prevent drought from entering injuriously; but this is a state of things that can only be obtained where the climate can be relied upon, whereas in clay deep-ploughed in autumn all that is required is to guard against working the soil while wet and leaving a smooth surface: we therefore never leave the land with either a harrowed or rolled surface, always letting the land rest after the grubber, which brings the clods and roots to the surface, and leaves the land in hollow furrowed lines where the coulters have passed through the soil. The battering effect of wet weather is thus nullified by the clods and furrowed surface, while the furrowed shape of the surface induces the bulk of the rain-water to get into the hollow, where the coulter has left an open fissure, facilitating its escape into the subsoil, thence to the drains or other outlets, and preventing the excessive washing of the soil.

We feel it our duty to give our experience of failures in deep cultivation, with the causes thereof. First, we have never found our deep system wrong upon clay soils; secondly, we have seldom found it beneficial on sandy soils; indeed, on real sandy soils we do not hesitate to state from experience that deep cultivation is injurious, but upon light calcareous sand we have found it highly beneficial—the action of frost and atmospheric changes break up and reduce the minute limestones, giving the soil more body and tenacity, thereby rendering it fit to grow heavier crops of cereals. On all rocky, stony, or gravelly soils, we have found deep cultivation to be the sound and correct system; but where deep cultivation has had the most immediate and also lasting effect is in soil of a light vegetable or moory nature, provided the subsoil was anything but white or black sand, and was ploughed up and incorporated well with the soil. As to the chalk hills, we cannot give any opinion from actual experience; but thus much is certain, that the farmers on the Yorkshire wolds are perhaps the shallowest cultivators in the kingdom, while, if we judge by the cleanliness and abundance of their crops, they are scarcely excelled by any other

district in the kingdom; yet we must own that during our sojourn in that famed district we noticed that the cottage allotments were growing better crops than the farms, although, as is too frequently the case, the allotments were on the thinnest-soiled land: the superiority of the crops we mainly attribute to deeper cultivation. We will just mention that our observation upon allotment cultivation has been, judging from their crops, in their favour, and against the farmer's shallow cultivation, except upon sandy soils, where shallow cultivation with sheep-treading produces the best crops. We have also found deep cultivation injurious on fen or bog soils, where the plough brought up either black or red peat or turf, unless (as was our practice) the peat or turf was first raked together and charred, in which case it acted beneficially. We would caution parties against dipping deep at once, and bringing up so great an addition to the staple, where artificial or other light manure is to be the preparation for the crop; but where a liberal dressing of farmyard manure is to be used, there will be advantage in going fully half the original depth of cultivation deeper, until the maximum of a foot or whatever is desired is obtained.

We will here give what we have found the quickest and best mode of deepening soils, so as to obtain depth with an abundant supply of vegetable matter, wholly changing the character of the land in one season.

After autumn-cleaning the surface, plough double the depth the land has been previously cultivated (taking a foot as the maximum), and performing the work as we have described, viz. with the furrow-slice laid over on edge, laughing at its cheerful and healthy position, experiencing the pleasures of every change that takes place in our fickle climate, so that by the middle of March every individual atom will be ready for a general dance, to the music of the harrow, roller, and grubber, by which the high and low, rich and poor, atoms, will be all well reeled and mixed together. Half a bushel of white mustard-seed should then be sown to the acre, and lightly harrowed in. As soon as it is well brairded, and on the point of going into rough leaf, let a hundredweight of nitrate of soda be applied to the acre; this will force it into a good crop a yard in height by the middle or end of May at the latest. Whenever the first blossoms drop and the embryo seed-pod makes its appearance, plough the whole in 6 inches deep, with the lime-cart applying from 10 to 15 quarters of lime to the acre, close after the plough; the harrow close after, followed by the sowing machine, sowing half a bushel of white mustard per acre, lightly harrowed in, followed by a light roller.

This crop will grow a fourth higher and heavier than the former one by the first week in July, when it will be fit for ploughing in nine inches deep. The same process of sowing half a bushel of mustard goes on again, which will be fit to plough in by the second week of September at latest, when it should be ploughed in the full depth that the land was ploughed the previous autumn, and, after laying a few weeks, a crop of wheat may be put in, without the least doubt about there being an abundant crop, provided that, after sowing, the press or clodroller is used, and again in March and April, when 3 cwt. of salt should be applied per acre: if the land is at all of a soft or spongy nature, let it be fed off by sheep in April and again press-rolled. In the year 1843 we put a piece of poor, spongy, thin soil, upon a stiff yellow clay subsoil, through this ordeal of management; the result was a produce of 41 bushels of wheat per acre. It was ploughed up after the wheat was off, when it worked like a garden. In spring, oats were sown, which yielded 78 bushels per acre; the field then went to root-crop and regular rotation. The same season we adopted the same plan with another wretchedly poor piece (but naturally good land), the soil light and shallow, upon the Northampton ironstone subsoil. The soil had been previously cultivated the full depth, about five inches; we ploughed it ten, bringing up the rotten ironstone which we had previously subsoiled. We then put it through the mustard process, as before stated, after which it was sown with wheat; then some turnips were drawn and thrown over it for sheep, which were kept upon it until it began to braird; the land was twice press-rolled in spring with Crosskill's roller, and salted with 3 cwt. per acre. The yield from this piece was 38½ bushels of wheat per acre. This was a piece of land that had been in tillage from time immemorial. Both pieces were first laid dry by drainage 3½ feet deep in 1840; both these pieces of land have since been well worthy the name of good land, and with fair management they will continue to yield abundant crops, having a deep and fertile staple of soil to work upon.

We think it right to state that we have experienced some very unprofitable results from sowing wheat upon land deeply ploughed after clover, beans, and potatoes, before we got the knowledge of applying Crosskill's roller, or sheep-treading, after sowing and again in the spring, and applying 3 cwt. of salt per acre. We have satisfied ourselves by a series of experiments that extra-deep cultivation is only useful for green crops, where liberal farmyard manuring must be applied after each extra depth is brought into action. When the full depth desired is obtained, artificial manure will by itself grow

abundant crops. Subsoiling we have practised (with a variety of results) for the past thirty years, *before*, *immediately after*, and *years subsequent to* drainage, the result of which we may thus sum up. First, always injurious before draining, with the single exception of the case where there is an impervious floor or pan betwixt the soil and subsoil, the latter being more or less porous, and giving some vent for the escape of the water. Secondly, we have never benefited by subsoiling stiff clay unmixed with stones or sandy veins, although we have decidedly received damage by subsoiling clay, but never from ploughing clay deep. We found that on all subsoils where there are considerable quantities of stone, large or small, subsoiling was followed by the best results; on sand it never has done good in any one case. We have found that, where subsoiling is done before drains have had time to get into operation, the land has been longer before the beneficial effects of the drain have been brought into play. We apprehend that the reason is that the breaking up and stirring of the subsoil cause the already imperfectly formed pores to fill up by the first heavy wet, making the whole mass settle down like a plaster floor; whereas a few years after drainage the pores get organised into regular channels leading to the drains through the subsoil. We have found it always best not to subsoil for at least two summers after draining; when it is done, let it be for the fallow or root crop, but not with the autumn ploughing; in spring, give a cross ploughing the full depth, subsoiling as deep under the plough as you plough in performing this operation. There are few who do it well, as they allow the horses to walk in the furrow upon the already loosened subsoil, making it a more compact mass where the horses tread than it was before. This we have for more than twenty years avoided, by arranging the draught of the horses drawing the surface-plough so that they all walk on the unploughed land.

We give drawings of our arrangements for three, four, and five, up to twelve horses, so that our readers may be able to get these necessary articles made before commencing the operation.

It will be observed that in all these arrangements the chief objects in view are, first, that each horse should draw his fair share; secondly, that the horses shall go as close together as is consistent with free action, so as to bring the line of draught as directly in the traction line of the plough as possible, thus reducing the necessity for setting the coulter-edge off the land, in order to keep the plough in the proper path. We have found the three and five horse arrangements well adapted for this purpose, as they make the centre line of draught about right for the line of plough-traction. For subsoiling the same

arrangements are required; therefore we have generally used eight horses, three in the plough and five in the subsoiler: if the work is easy, walk fast; if hard work, give more time; and if more power is required, use five horses in each; the expense we have never found more than two common ploughings requiring the same number of horses, as we have always had from an acre to five roods done per day, indeed often six roods.

Our mode of keeping horses has been liberal: during the winter eight months two bushels of good oats, half a bushel of beans, and half a hundredweight of hay cut into chaff, with straw *ad libitum*, weekly: and in summer a bushel of split beans, with as much green Italian rye-grass and clover as they wish. By looking over our books, we find that the following is about what has been the average expense of ploughing and subsoiling upwards of five hundred acres (the plough going 8 inches, and the subsoiler 8 inches deep), when done with eight horses, three in the plough and five in the subsoiler:—

	£.	s.	d.
Eight horses a week, at 12*s.* 6*d.*, including insurance ..	5	0	0
Two men, at 14*s.*	1	8	0
Three lads, at 6*s.*	0	18	0
Tear and wear of ploughs, harness, &c.	1	14	0
Six acres, at 30*s.*	£9	0	0

This is rather over than under the actual expense, therefore it is a safe basis for calculation. We have not had any digging and subsoiling done in England, but have done a little by ploughing and subsoiling with strong two-tine forks, the plough drawn by five horses going 10 inches deep, and the men going 8 inches into the subsoil with the forks; we found that it was hard work for twenty men to keep up to the plough; we did only two acres and a quarter in two days of nine hours' work each, but, the weather being fine, we think that an acre a-day would be a fair average for good effectual work on such very strong clay land, upon a stiff blue clay subsoil. The expense stood thus:—

	£.	s.	d.
Five horses, at 2*s.* 1*d.*	0	10	5
One ploughman, at 2*s.* 4*d.*	0	2	4
Two lads, one leading, the other driving, at 1*s.* ..	0	2	0
Twenty men subsoiling, at 2*s.*	2	0	0
Tear and wear of tools, plough, and harness ..	0	5	8
Making the total cost per acre	3	0	5

In the same field alongside, we did one acre the same depth with Gray's subsoiler, drawn by five horses; the work we thought

but little if at all inferior to that done by the fork; this was done easily in a day. The expense stood thus:—

	£.	s.	d.
Ten horses, at 2*s*. 1*d*.	1	0	10
Two men, at 2*s*. 4*d*.	0	4	8
Three lads, at 1*s*.	0	3	0
Tear and wear	0	6	0
Making a total cost per acre of	1	14	6

Proving the subsoiler more economical by 26*s*. per acre.

The rest of the field we did not subsoil, but ploughed the same depth, except one ridge, which was ploughed 5 inches deep, being the full depth of previous cultivation; all those operations were performed in the March of 1840. The whole field was afterwards grubbed, harrowed, rolled, and ridged, well dunged, and planted with potatoes, the ridges crossing the direction of the ploughing; the crop was four times horse-hoed, and twice moulded up: they turned out an excellent crop, there being no difference worth note in the subsoiled part, but the ridge only ploughed 5 inches deep produced 23 cwt. less to the acre than the rest, which was ploughed 10 inches deep; we sold the potatoes at home for 2*s*. a cwt., so that the extra crop, by deep ploughing, was sold for 46*s*. an acre, while the extra depth of ploughing cost only 9*s*., thus leaving a profit equal to rent and taxes. The whole field was sown with wheat in three equal parts, one ploughed 10 inches deep, another 5, and the third ploughed with one-horse ploughs 3 inches deep and 7 wide; one half of this part had the seed ploughed in, the other half was drilled; also one half of each of the other two parts was drilled, the rest sown broadcast and harrowed in. The whole was done with the soil in that state we like best for wheat-sowing, namely, wet enough not to smear. Each was thrashed separately, giving the following results: ploughed in, 34¼ bushels, weighing 62 lbs.; harrowed in on 5-inch ploughing, 31 bushels; and on the 10 inches deep 29½ bushels. The three drilled pieces stood thus:—

Three-inch ploughing	32 bushels.
Five-inch ditto	31¼ „
Ten-inch ditto	27 „

The weight of straw was not taken, but the bulk was in favour of deep ploughing; the quality of the grain was decidedly in favour of the shallow ploughing. As far as the eye could judge, the potato crop had exhausted the whole benefit of the manure on the part that had never been ploughed deep, as the straw was at least a foot shorter, and the ears generally one row of grain

shorter. On the unsubsoiled part the crop was the most even and had the brightest colour; the subsoiled part was weak in plant all winter and spring, and although it recovered wonderfully, and looked a fine crop at harvest, the straw was not so bright nor the grain so plump and good as the rest; on the other parts these defects increased with the depth the lands were ploughed for the wheat crop. The following autumn we attempted to plough this field a foot deep for turnips, but were unable with five horses to accomplish it, because the clay subsoil that had been moved by former subsoiling was doughy and adhesive and would not clear the plough. That which had never been moved did clear the plough well, and we could have accomplished the twelve inches on this part, but, wishing to keep to our rule of ploughing across the line of the former deep ploughing, we ploughed it 10 inches deep again. We tried several similar experiments, both in this country and Ireland, but always found subsoiling clay, if not injurious, at least useless.

A field of light land (soil made eight inches deep by our former ploughing), drained in 1840; subsoil Northamptonshire ironstone intermixed with clay—we ploughed a foot deep in the autumn of 1843, and subsoiled 9 inches; the whole was grubbed with Smith's grubber 8 inches deep in March, and again in April, then well manured with 40 cubic yards of green or long dung, and planted with potatoes in ridges 28 inches wide, which were four times horsehoed 10 inches deep, twice handhoed, and twice moulded up with a deep-bodied Deanston subsoil-plough, having a pair of mouldboards fixed high enough to allow of stirring the subsoil 10 inches below the bottom of the ridge furrow. It will be remembered that this (1844) was an extraordinarily dry summer, scarcely any rain falling from March to the end of September; in fact, we noted particularly that the land was never wetted an inch deep by rain, from the planting of this crop till October; yet the whole 25 acres averaged over 15 tons of potatoes (of superior quality) per acre. As a preparation for the seed, this field was all ploughed 4 inches deep, except one acre which was ploughed 10 inches: the whole was drilled with wheat, which produced an immense crop of straw—soft and laid as if rolled in that part which was deep-ploughed, the rest only laid badly in patches. There was much blight in those parts that were laid, all the deep-ploughed part worse blighted than any other of the laid parts. We did not keep it apart, therefore the whole was thrashed together, yielding 32 bushels 2 pecks per acre, weighing 62 pounds a bushel. After the wheat it was again ploughed a foot deep for turnips, which were an excellent crop, above twenty tons per acre, followed by oats that yielded above nine quarters per acre,

succeeded by an excellent crop of seeds. These are some of our experiments, the whole record of which would fill a book, all proving the utility of *deep cultivation* for roots and fallow on clays and all other soils, except sand and peat or red bog; also proving that *subsoiling* acted beneficially wherever there was a mixture of stones in the subsoil, but was of no benefit, if not injurious, on clay or sand subsoils. Now, as to the best implement to subsoil efficiently; we have never found anything capable of breaking up hard stony subsoil perfectly, except Smith of Deanston's plough, with a wheel to guide the depth; and for ordinary gravelly loams, or gravelly and sandy clay, Gray of Uddingston's subsoiler, which got the prize at Lincoln, meets our wants best: Read's subsoiler did more to put the operation out of use than any other thing we know of, and we found that by its use we sacrificed efficiency at the shrine of reduced draught, except in stiff clay while in a dry state; it makes a mere rut in the middle of the furrow, leaving at least two-thirds of the subsoil unmoved, and jumping over all the hard parts.

We have not trench-ploughed any land in this country, except a few acres of old grass, when first breaking it up, and that was only ploughed 2 inches deep by the first plough, and from 5 to 6 by the second; an acre was ploughed 8 inches deep, and all the rest was ploughed 5 inches, the whole done during the winter of 1841, and, after applying ten quarters of lime, sown with oats in March; in May 3 cwt. of salt was applied per acre. The crop was evidently the best on the shallow or 5-inch ploughing; and that on the part trench-ploughed was not a whit better if as good as that ploughed the same depth at one operation. The whole piece yielded above 10 quarters per acre. It was all ploughed 10 inches deep in autumn, prepared by grubber in spring, and planted for potatoes without manure; but, after harrowing down the drills 6 quarters of lime and salt, which had lain mixed three months, were spread per acre, and immediately the drills made up again with the double-moulding plough and again harrowed down, as the potatoes were then almost through the ground; the whole produced an average of 11 tons per acre. There was no difference in favour of, or against, the parts either ploughed deep or trench-ploughed for the former crop. The subsoil was a cold stiff clay free from stones, therefore we did not subsoil. This field was drained 3½ feet deep before ploughing for the oats.

While in Ireland we drained a field of what is termed bottom land; the soil of which has the appearance of being the last few inches of turf bog left, after all the rest had from age to age been used as fuel. This field had about 7 inches of black bog-soil, under which was the drift of the mountain

limestone mixed with sand. In July and August, 1832, we trenched one-fourth of this by spade and one-fourth by plough, 14 inches deep; that trenched by spade cost 4*l.* 3*s.* 4*d.* an acre, the subsoil nearly all requiring to be worked with the pickaxe, and then shovelled over the top of the black soil. The trench-ploughing was done with two ploughs, the first drawn by two horses, going 7 inches deep and 10 inches wide; the second plough loaded with a cwt. in the body of it to keep it steady, and drawn by four horses yoked with equalizing swingle-trees; in fact, it was here we were driven to the invention of these indispensable appendages to deep ploughing with high-spirited horses. The last, or trench-plough, took up 7 inches out of the bottom of the preceding plough's furrow and laid it on the top; thus the soil was completely covered with subsoil, making a white field out of a black one. The rest of the field was ploughed 3 inches deep with a double-coulter plough, that is, one coulter in advance of the regular one, cutting the furrow-slice along the middle about 2 inches deep; thus each furrow-slice was cut longitudinally nearly in two, making strips 4 inches wide, while the ploughing was done 8 inches wide. This part was then well rolled with a heavy stone roller and left until November, when it was ploughed across 11 inches deep with six horses, three and three abreast, the plough being loaded with a cwt. in the body to keep it from rising out of the hard gravelly subsoil. The whole field was reploughed across and well prepared and sown with turnips, manured with 20 bushels of bones mixed with bog-mould and saturated with dung-water for several weeks before use. The crop of turnips, white globe and red Norfolk, was excellent; but the half that was first ploughed shallow and then deep produced much the best crop, and the crop of oats afterwards was also the best; but after being again ploughed 10 to 12 inches deep, and subsoiled 8 inches under that, a crop of swedes grown with 40 cubic yards of dung was much the best on the half of the field that was trenched for the former turnip crop; though we could not see any difference in favour of the spade over the trench-ploughing, although the expense was more than double. After the swede crop we never could discern any difference in favour of the trenchings. It is right to observe, that, from the decay of the vegetable matter of the boggy soil causing it to subside, every time the land has been ploughed 12 inches deep a little fresh gravel was brought up: this field has produced crops nearly equal to those of the best land.

Another field, where the grass was of the very roughest description and the bog-soil 10 inches deep, after drainage was

trenched thus:—first spitful 10 inches, and then 8 inches of the gravel dug up and laid on the top, in July and August, 1834, at a cost of 5*l.* the acre. The trench-ploughing was so unsatisfactory, that we only had one acre done; three acres were ploughed 3 inches deep, and again 12 inches deep in October; the whole was cross-ploughed 12 inches deep in March, and then prepared for turnips, which were manured with bones and well and deeply worked. The part trenched by spade produced nearly double that of the part not trenched, and above a third more than that trenched by the plough: the oats after the turnips were equally in favour of the spade-trenching against that plough-trenched; and the part not trenched at all had a great bulk of straw, but the grain was deficient in both quantity and quality, showing the want of the gravel. This part was then trenched also, and the rest ploughed and subsoiled, after which it went into regular rotation and cropped well. From these and other experiments we concluded in favour of trenching wherever the depth of bog-earth was not more than 8 inches deep, as that and less depths could be ploughed so as to bring up a fair mixture of subsoil to give weight, &c., to the bog-earth. The subsoiling we have found it best to leave until the second time of preparing for roots after drainage. By subsoiling, the decay of the bog-earth is hastened, and the subsoil sweetened, and prepared for being brought into action by future deep ploughings; the decomposition of the boggy soil permitting it to be gradually reached on each return to the preparatory deep ploughing for root crops.

In the summer of 1827 we assisted in the draining of a field of deep red bog that was not firm enough for horses to get upon, so that all the operations were done by hand: we sunk the drains 5 feet deep, going through the bog and a foot into the sand below. These drains had 18 inches of thorns firmly trampled into them, upon which the surface-turf was laid; they were then filled in and well rammed down, to keep out the air as much as possible. The total expense was 3*l.* 10*s.* per acre. The whole field was trenched 20 inches deep, burying the surface, spongy, mossy soil, and bringing up the black, soapy, rotten under-soil, at a cost of 6*l.* per acre; it was then covered with 80 cubic yards per acre of a mixture of red clay and gravel (provincially termed *till* in the west of Scotland) at a cost of 4*l.* per acre. After this it was left until the following March, when 50 cubic yards per acre of coal-ashes and nightsoil, drawn from Glasgow, at a cost of 10*l.* an acre, was forked in and well mixed with the soil 6 inches deep, in the first week of April: the whole was hand-drilled with Altringham carrots, which were managed altogether by hand, at an expense of 4*l.* an acre, including the digging up. This was

perhaps the most successful bit of spirited farming it has been our lot to have anything to do with, as the crop yielded over 31 tons of carrots the acre, which were sold to the Glasgow greengrocers at an average of 5*l.* per ton; thus leaving a profit the first season of more than double the fee-simple of the land. Half the field was ploughed shallow and sown with oats, which grew abundance of straw but no grain; the other half was again sown with carrots manured with soot, but the crop fell off to 20 tons, and the price to 75*s.* a ton, reducing the return to half.

This field was cropped with oats and carrots alternately until we left for Ireland in 1832, and perhaps no piece of land ever made so much money as this did in return for high manuring and deep cultivation, but of course the near market for the roots was the available means of making those profits. The land which lies in an unprofitable state of nature in the neighbourhood of large towns, growing a scanty produce of meadow hay, which is frequently the case in England, shows that in such situations capital and intelligence are attracted into other channels.

The only hand cultivation we ever saw that had the recommendation of economy on its side, as compared with the plough, was in the spring of 1850, when we were called upon to officiate in adjudicating awards for digging with forks 12 inches deep, which took place on Mr. Walter's farm near Greenhithe in Kent, where the men, fifteen in number, each dug in one day four square poles of strong clay and nine square poles of light deep soil upon the chalk formation (but having several feet of drift between it and the chalk); this they did in a most efficient manner, while on the opposite side of the fence we saw four splendid horses hauling an unwieldy turnwrest plough, going 7 inches deep, with one man holding and another driving. From what we saw, as well as from information, an acre is in that neighbourhood much more than a general day's work throughout the season.

Now, if we take fourteen men to dig an acre 12 inches deep, finding their own tools, ten could dig an acre 7 inches, which, at 2*s.* a day, makes 1*l.* per acre.

	s.	*d.*
Now four horses so near the Great Metropolis must cost 2*s.* 6*d.* a-day each for keep and insurance, making	10	0
One man	2	6
One lad	1	3
Tear and wear of harness	1	3
	15	0

We think there are few farmers who would not dig a considerable part of their land if they could get it done at these

prices, which we were told by these labourers they would be willing to undertake to do; the land dug would afterwards be prepared for a crop for at least five shillings per acre less than that after the plough, at an equal depth, as the forks leave the soil perfectly free from any of that pernicious glazing effect, so much admired by ploughmen, but detested by all gardeners and philosophical farmers.

Fourthly, Is pulverisation sufficient without inversion of the soil? As a short answer to this question, we (from some few years' experience) say No; but to a considerable extent in the operations of cultivation we say Yes!

We will detail our experience in this matter. Having in 1840 invented a grubber (made by Messrs. Smith of Paisley) with which we thought of superseding the plough, we began our experiment upon a field that had been treated as follows:—Ploughed after clover; the soil a first-rate loam, part upon Northampton ironstone and part upon a yellow clay subsoil, the staple being generally from 6 to 10 inches deep: 8 quarters of lime applied before and 12 after ploughing it 5 inches deep; one acre we only ploughed 3½ inches deep. The whole was sown with wheat drilled; during the spring all (except the shallow-ploughed part) lost plant very much, but we put the whole of our sheep upon it, giving them some turnips thrown about, to induce them to run about and trample it as much as possible, and applied 3 cwt. of salt per acre. This had the effect of establishing and invigorating the plants, causing them to stool or tiller rapidly. There were 34 bushels (of 62 lbs.) per acre on the 5-inch ploughing; but 37 bushels on the shallow or 3½-inch ploughing. After autumn scarifying and cleansing the stubbles, we ploughed two-thirds of the field 12 inches deep; the other third we cultivated with the grubber to the same depth, by going three times over the ground in different directions, thus expending as much for grubbing as was expended on the other part for ploughing. In March, when the first spring grubbing took place, the ploughed part was decidedly the easiest draught for the six horses which were required to work it up to the full depth; one acre of that previously ploughed was again cultivated with the plough instead of the grubber; the whole was prepared and sown with swedes, manured with 24 cubic yards of farmyard dung, long and unfermented, and 16 bushels of bone-dust, mixed with ashes and wetted with dung-water some weeks before use. The whole field was sown upon the ridge; all came up and went on well, except the acre that was three times spring-ploughed instead of being grubbed. The

effect of the ploughing (as usual) was shown, first, in drying the soil too much; secondly, in imperfect pulverization. To these causes we attribute the irregularity of the braird of the swedes. The whole was twice horse-hoed with a light shallow paring or weed-destroying horse-hoe, and at the same time singled and hand-hoed. When the plants were strong and about a foot across the foliage, the grubber horse-hoe went through, first 4 inches deep, then 8 inches, then the full depth of the worked soil, namely, one foot; a fortnight intervening between each operation. The whole was a first-rate crop, but the part wholly cultivated by the plough rather uneven in plant. In the end of November we had four square poles of the average of each weighed, after clean topping and tailing:—

	Produce per Acre.
No. 1. By plough cultivation	19½ tons.
No. 2. By plough and grubber cultivation	23¼ „
No. 3. By grubber alone	21½ „

The whole crop was drawn off and the field sown, one-half with April wheat and the other with oats, all drilled across the line of cultivation, after being prepared in the following way:—

No. 1. Half ploughed 10 inches and the other half 4 inches deep.

No. 2. The same.

No. 3. Half was grubbed 10 inches and the other half 4 inches deep. The whole was sown the last week of March, and was dressed with 3 cwt. of salt per acre the beginning of May. The whole field was sown with Italian rye-grass and broad clover the last week of May and hoed in.

	Oats. Bushels of 41 lbs.	Wheat. Bushels of 62 lbs.
No. 1, ploughed 10 inches deep, produced ..	90	38
„ 4 „ „ ..	83	42
No. 2 „ 10 „ „ ..	91	37½
„ 4 „ „ ..	85	41¼
No. 3, grubbed 10 „ „ ..	84	34
„ 4 „ „ ..	80	38

Although the season was very dry, the seeds were an excellent crop. They fed off six ewes with their lambs per acre; two acres were mown for our horses, and directly after each mowing it was manured at the rate of half a cwt. of nitrate of soda and one cwt. of guano mixed per acre. This yielded four mowings, keeping ten horses from the 12th of May till the end of August, each horse having a bushel of split beans a week. We observed that on all the parts deeply cultivated for the grain crops the seeds were much the best, but we could discover no difference for or against the grubbed part No. 3. There being a capital lot of sheep keep, which after this dry season was too valuable to

plough in, we resolved to leave the field for oats, and in September applied 20 cubic yards of dung per acre, which gave the grass an impulse, and, after six weeks' rest, it wintered five ewes to the acre, with the aid of half a pint of oats and a little chaff each per day, from the 1st of November till the last week of March, when the whole field was prepared for a crop of Hopetoun oats, in the following modes: the whole was drilled the first week of April, the land being in a most favourable state for receiving the seed, and hoed in May, when 3 cwt. of salt was applied per acre:—

	Bushels of 41 lbs. per acre.
No. 1, ploughed 10 inches deep, produced	101
„ 5 „ „	92
No. 2 „ 10 „ „	102
„ 5 „ „	93
No. 3 was all broad-shared, harrowed, and rolled while dry, to kill the grass; half was twice grubbed 10 inches deep; produced	85
Ditto, 5 inches deep	72

No. 3 was hoed twice, No. 1 and No. 2 once; there appeared quite as much straw per acre on No. 3; in fact, there was the same number of sheaves, but the straw was not so bright and the oats were more chaffy and worse to thresh: taking the whole together, it was the finest field of oats we ever saw grown, the straw being higher than a man.

In September, 1845, the field was prepared for wheat, each part in the same way as for the oats; we applied 3 cwt. of salt per acre after sowing, and 3 cwt. again in April with 3 cwt. of guano, hoed in. We should mention that we rolled the whole well after sowing with Crosskill's clodcrusher, and again in March:—

No. 1, ploughed	10	inches deep,	produced	34	bushels of 62 lbs. per acre.
„ ..	5	„	„	41	„
No. 2 „ ..	12	„	„	32½	„
„ ..	8	„	„	37	„
„	4	„	„	42½	„
No. 3 grubbed	12	„	„	28	„
„	8	„	„	30½	„
„	4	„	„	35	„

In No. 3 we found, that, though all the conditions of cleanliness and thorough pulverization were complete, the want of aëration was strongly shown, proving that it is essential, because the whole of this piece, on close inspection, showed a great want of silica on the straw; in fact, it appeared to us like straw grown upon a bog, being a dingy light brown rather than yellow. The whole was much laid, and the quality of grain much inferior to the rest. The quality in all the lots may safely be taken as declining equally with the quantities, for the bulk of straw was

generally in an inverse ratio to the quantity of grain. This whole field was peculiar for the manner in which it showed the effects of deeply preparing the soil for wheat in the following ways:—

1st. Greater bulk of straw of a soft description, much laid, in fact laid in proportion to the depth of cultivation.

2ndly. Later ripe, also in proportion to depth.

3rdly. More chaffy, which gave the ears an imposing appearance in size. The brightness and stiffness of wheat-straw we have for many years observed to increase with the shallowness of the preparations for it; at least it has been so in our case, where the land has a staple either naturally deep, or made and kept so by deep and effectual fallowing for roots, &c.

After this we were satisfied that exposing the soil to the action of the air has indisputably a beneficial effect, especially if the land is thoroughly and deeply ploughed in the autumn in such a way as to expose the greatest surface and body of earth to the influence of the weather during the winter. Our experience satisfied us that no more ploughing is required in preparing land for roots, &c., unless some other object is in view besides the pulverization of the soil, such, for instance, as the ploughing in of manure, &c.

We will now describe the way in which we began a new system of deepening strong clay land, at the same time changing it into a loam and good turnip soil.

The plan is, after autumn cleaning the stubbles, to plough the land the same depth as the good earth; in April harrow it well, then plough 2 inches deeper than the former ploughing, turning the furrow completely over, and laying the subsoil on the top; or with the trench-plough bringing up 2 inches of clay to the top. When this clay becomes partially dry, harrow across 2 or 3 times with a set of Howard's or Williams's heavy-land harrows; take a strong horse-rake and collect all the clods into rows; then light fires 22 yards apart, using a good thorn faggot to kindle each heap, adding clods and finely broken coal or coaldust in alternate layers as the heaps burn up. Thus there will be 10 heaps to the acre, containing about 16 cubic yards of burnt clay each, which will cost for *collecting* out of the rows left by the horse-rake; *burning* (including coal at 10*s.* a ton); and then *spreading*, from 60*s.* to 80*s.* an acre, accordingly as the weather is wet or dry; the operation in fine weather takes about a fortnight. After the heaps have burnt 4 or 5 days, they will not be put out by a fall of 2 inches of rain, which is the full average monthly fall. The hands required are 3 men to 2 acres. After spreading the ashes, which should be done by the 1st of June, plough them in half the depth of the former ploughing, and sow half a bushel of white mustard to

the acre: this will be ready to plough down in 7 weeks after sowing, and should be ploughed in 2 inches deeper than the former trench or deep ploughing, again bringing up 2 inches of clay, which should be prepared and burned in the same way; then ploughed, or, better still, well grubbed, and stirred up 4 inches deep, when wheat may be drilled without fear of the result. We must admit that our experience has not been great in this system, but from what we have done we feel justified in urging it upon the owners and occupiers of well-drained clay soils.

We have given all the information it is in our power to give, as far as we can deduce it from our humble researches after sound practical principles in connexion with the cultivation of the soil, and we may sum up in the following order:—

First, as to the safest, and therefore the best, way of deepening the staple. On soils having stony, gravelly, or calcareous subsoils, it is best to stir the subsoil with the subsoil-plough previously to bringing it up to mix with the staple, and this should not be done for at least two years after drainage. All sandy soils where there is less clay in the subsoil than in the soil should not be cultivated deep, as we should only hasten the escape of the clay, which is our best friend. We may remark here, that we have derived immense advantage from mixing one cubic yard of clay to six of the farmyard dung intended for sandy soils.

On bog or peat where the under peat is red and spongy, it is positively injurious to plough deep, though it might be beneficial to subsoil it to encourage decomposition. We know it to be very beneficial to plough the under strata up in dry weather and char it, and thus deepen the staple.

We think that what we have advanced will go far to show that the best way of deepening the staple is to increase the depth of cultivation, whether by the fork, spade, or plough, early in *autumn*, adding not more than one-fourth additional depth to your staple, and that only before a well-manured green-crop, unless the mustard course of preparation is preferred; as we feel assured that a due admixture of vegetable matter is required to complete the functions of the laboratory of nature, and supply the various crops with their food properly prepared. It will be found in the foregoing remarks that our answers to the four heads or divisions of this subject are as follows:—

1st. Deep ploughing, comparative effect of, at spring-time and autumn.

Is decidedly the best performed in autumn, to secure the rub of the winter's weather.

2ndly. Subsoil-ploughing, especially upon lands recently drained.

Our experience is against performing this operation for at least two years after drainage, and shows that it is injurious on all unmixed clay or sand subsoils.

3rdly. Trench-ploughing, forking, digging, &c.

On this subject we are convinced that there is no prudence in burying a better soil than we bring up, unless an extraordinary quantity of rich manure is to be applied to compound a good soil out of it; but, as we have shown, when the soil is light and spongy and the under strata of a heavier description, then trenching is at once adding fertility to the soil, as in the cases of bog upon any earth or decomposed rock, or sand upon clay, or even clay on sand, or where the subsoil contains lime: in such cases trenching is beneficial to the farmer.

4thly. Is pulverization sufficient without inversion of the soil?

To this our experience says No; but it says that pulverization is sufficient with occasional inversion—that is, once for each crop.

Here we have spun our yarn, and hope that others, as well as ourselves, may be able to deepen the staple of our cultivated acres, so as to yield greater abundance of bread and meat, and thus render our posterity less dependent upon other nations for the necessaries of life than we now find ourselves.

Description of Draught-equalising Swingle-trees, as represented in the Drawings Nos. 1, 2, and 3.

Figure 1 represents a full set of draught-equalising swingle-trees for either three horses abreast, or six three-and-three abreast; the equalisers A A dividing the strain upon the draught-chain H into three equal parts, to each of which the swingle-trees B B B are attached, forming a complete set for three horses abreast as shown by the Nos. 1, 2, 3.

Figure 2 represents a set of equalising swingle-trees for any number of horses from two to six. The figure represents the arrangement for five horses, three in the furrow and two on the land, as shown by the Nos. 1, 2, 3, 4, 5.

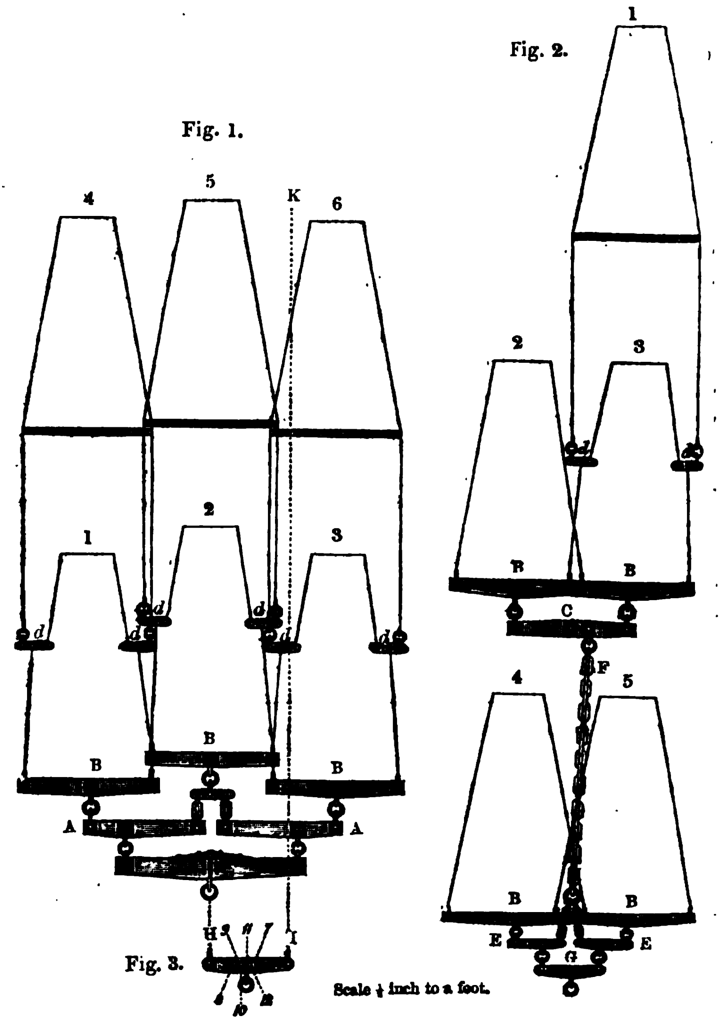
When six horses are to be used in three pairs, two abreast, add another pair of fore-horse equalisers, *d*, before horse No. 2, to which yoke the sixth horse; at the same time alter the chain F into the centre hole of the equalisers C, also shifting the two end attachments of the master-tree G to the holes of the equalisers E E nearest the end, which completes the arrangement for six horses two-and-two abreast.

When four horses are to be used, to alter the arrangement from six to four, either detach the chain F from the equaliser C, and attach the implement or draught-chain to C, taking away the last two horses.

Another way is by detaching the two fore horses with their tackling, at the same time changing the ends of the master-tree C into the centre holes of the equalisers E E.

When three horses are used, then use the fore part of the set represented in the figure, attaching the implement or draught-chain to the equaliser C, taking away the last two horses Nos. 4 and 5.

When two horses are to be used, then detach the fore horse No. 1 with his



DRAUGHT-EQUALISING TREES. P. LOVE, Inventor, in the Year 1834.

tackling, and attach the implement or draught-chain to the centre hole of the equaliser C, thus making a complete set of common two-horse swingle-trees. We may mention that we have used blocks and pulleys in place of the side equalisers *d d*, but found the tear and wear very great, although they certainly work beautifully.

Figure 3 is a Samson-equaliser, for connecting both of these arrangements so as to equalise the draught of seven, eight, nine, ten, eleven, or twelve horses, where herculean work is to be done. These arrangements are accomplished thus : the Samson-tree is attached to the implement, and the end H to the six-horse set of trees ; then to the end marked I the long chain or wire-rope K is attached, which passes up between the middle horses and those in the furrow : to the end of this chain or rope in front of the six horses attach Figure 2 set

of equalisers, arranged so as to work any required number of horses, which will, when added to the six, make the number you desire to use, shifting the pin that connects the implement to the Samson into the hole that is marked with the number of horses you are about to use, and all will be right. For seven horses use three abreast behind, and four two-and-two abreast in advance, with the Samson arranged for seven horses.

These arrangements are so simple, that by any ordinary capacity they will, on a little inspection, be quite clearly understood.

February 25, 1856.

XX.—*Report on the Exhibition of Sheep and Pigs at the Chelmsford Meeting of the Society*, 1856.

[In consequence of the lamented death of Mr. Woodward, Senior Steward of this department, the Report on the Exhibition of Live Stock at Chelmsford is confined to the few following remarks, communicated by Sir Stafford Northcote, Bart., M.P.—Ed.]

Leicester Sheep.—The number exhibited was considerably less than last year. In Class I. (shearling rams) there were only 34 animals shown, as against 66 last year. In Class 2 (rams of any other age) 23 against 39 last year. In Class 3 (pens of five shearling ewes) only 3 pens against 14 pens last year. The quality of the animals exhibited was hardly equal to that of those shown at Carlisle; this was particularly the case with the ewes.

Short-woolled Sheep.—The show was good, and the numbers greater than last year. In Class 1, 58 shearling rams were exhibited against 36 last year. In Class 2, 40 rams of other ages against 18 last year. In Class 3 there were 15 pens of ewes against 5 pens last year. Some fine animals were exhibited, and Lord Walsingham's stock attracted special admiration.

Long-woolled Sheep.—There was little in this department that called for remark. The numbers were, in Class 1, 21 shearling rams against 36 last year; in Class 2, 19 rams of other ages against 18 last year; and in Class 3, 12 pens of ewes against 9 last year.

Pigs.—The show of pigs was good, especially of the small breed. The total number of entries in all classes was 111 as against 80 last year. In Class 4 (breeding sows of a small breed) the judges expressed their regret that there was not a second prize, as they would gladly have awarded it to No. 621, a sow belonging to Mr. G. Mangles, of Givendale, near Ripon.

It was satisfactory to find that the number of animals above the age stated in the certificates was very small. The precautions taken at Carlisle appear to have checked an abuse in this respect, which at one time threatened to be very serious.

XXI.—*Report on the Exhibition and Trial of Implements at the Chelmsford Meeting.* By William G. Cavendish.

Sir,—In forwarding the Reports of the different judges of implements at the late Chelmsford meeting, I observe with pleasure the continued increase of the number of exhibitors and of articles exhibited. The show at Chelmsford far exceeded in this respect all previous ones. Owing to the new classification of the implements, first adopted at this meeting, there was of course very much more time and attention given to the class under trial, viz. those implements used in preparing the land for seed. The strong-land field was so extremely hard that four horses could hardly do the work required in ploughing. The same was the case with the scarifiers; some of them were utterly useless on land in that condition, but had the land been left till after rain they would have worked with ease and efficiency. Mr. Boydell again exhibited his engine, drawing with ease any implements that were attached to it; and it still remains to be proved if it will ever be found serviceable in agriculture. Fowler's stationary plough, working by means of a wire rope, had never before been shown at any of the meetings of the Royal Agricultural Society; it did its work very well as far as could be ascertained, but there were so many people anxious to see it that it was found impossible to work it properly in such a crowd, therefore it was sent with the reapers to the adjourned trials at Boxted Lodge.

The ploughs in the light land did their work in such perfection that it was with the greatest difficulty that the best could be selected by the judges appointed for that trial.

The adjourned trials of the reaping machines, and of Mr. Fowler's steam cultivator, took place on the 13th and 14th of August at Boxted Lodge, near Colchester, the residence of Mr. W. Fisher Hobbs, under the direction of Sir A. K. Macdonald, one of the stewards of implements, who informs me that the Royal Agricultural Society, and all those engaged in the trials, were under great obligation to Mr. Hobbs, not only for his kind hospitality, but for the liberal manner in which he placed his men, his horses, and his crops, entirely at the disposal of the Society, and for the facilities which he afforded for carrying out the trials most efficiently. The very able and detailed Report of the judges on these adjourned trials will be found highly interesting.

William G. Cavendish.

The general assortment of field implements submitted for trial at the Chelmsford Meeting of the Royal Agricultural Society, did not exhibit any novelty in principle; but there was throughout the whole great improvement in the details, and in workmanship. The trials were more severe than usual, particularly on the heavy land, which afforded an opportunity of testing the

strength and quality of the implements on the stubborn clays of Essex, proverbial for their tenacity at one time, and hard baking qualities when exposed to the summer heats. Such was the case with the land where the trials took place. It was baked to a brick-like hardness; so much so that in ordinary operations the farmer would wait a more convenient season, and until rains had so softened the clods as to make them permeable to the action of the harrow, and the other implements that would follow.

The recent change in the mode of awarding the Society's prizes, which had occupied the attention of the Council for some time, gave a discretion to the Judges that required great care, so that the comparative merit of the respective implements might be arrived at. This, it may be hoped, has been done in some degree. The Judges, being fully aware of the importance of their decisions to the public, as well as to the exhibitors, have endeavoured to the best of their judgment to award to each implement on trial its due allowance of merit, as well as to point out such improvements in the working details as will, if carried out, be of advantage to both buyers and sellers. In making the awards, the Judges have been careful to observe the instructions given them, "of taking into consideration the selling price of the implements," being fully aware that complication adds to expence, while simplicity gives cheapness and effect in the field.

The first implements submitted for trial were the light-land harrows, intended for covering or preparing the land for seed-corn, or used in fallowing light land for roots, &c. These were really useful pair-horse harrows; and we subjoin below our awards, as well as some extracts from our note-book, which we hope will be received in good faith, and lead to further improvements.

LIGHT-LAND HARROWS.

Prizes and Awards.	Stand.	Art.	Exhibitor's Name.	Remarks.
£. s. d.				
3 0 0	132	22	Messrs. Howard.	For their moderate price, their peculiar zig-zag form, being jointed so as to suit round stetches, or flat lands; a simple contrivance of hoop-iron under the nut kept it in place. The harrows covered their ground well, cut deeply, and might be worked either way.
2 0 0	103	3	W. Williams.	For similar form and very good workmanship; teeth well arranged; moderate price, and worked well; similar to Howard's, but had no joint.
2 0 0	78	48	E. H. Bentall.	Very strong; made of double angle iron; the nut holding the teeth locked on by a rivet; worked well with single hooks only; double hooks generally to be preferred.
Very highly commended.	124	6	Messrs. Hill and Smith.	These harrows were made with cast metal teeth, fastened by a key in a wrought iron socket, which forms the rivet holding together the frame; the teeth drilled in back and front, so as to wear sharp. Owing to an accidental circumstance, the larger set of harrows were not tried on heavy land, which would have severely tested the cast metal teeth, and proved whether they would, or not, give way before the brick-like clods in the field. This appears to be the question. Production is cheapened by introducing cast metal into harrow-teeth, and time will prove their usefulness or otherwise. Under these circumstances the judges felt it their duty to give their highest commendation.

LIGHT-LAND HARROWS—*continued.*

Prizes and Awards.	Stand.	Art.	Exhibitors' Name.	Remarks.
£. s. d.				
Commended.	37	47	Messrs. Ransome and Sims.	The harrows in this class, made by the firm of Ransome and Sims, were of similar form to Howard's and Williams's, and of superior workmanship, having a diagonal brace with collared nuts to prevent the teeth getting loose. They were, however, defective in construction, being too short, which, like a short boat on the waters, caused them to pitch, and not work steadily. These harrows would be improved by bending downwards the draught hooks to counterbalance the weight of the whippletrees.
Silver medal.	97	13	Messrs. Phillips and Woods.	*Poppy extirpator.*—Useful for destroying small weeds in their *embryo* state (v. Catalogue); and it may with advantage be employed to harrow clover-seeds after a fallow crop.

GENERAL-PURPOSE HARROWS.

3 0 0	103	5	W. Williams.	These harrows were similar in construction to the lighter ones tried as seed-harrows (No. 3); workmanship good, and covered the land well; price moderate. They are fully entitled to a high position.
3 0 0	132	20	Messrs. Howard.	Equally good as No. 22, and on a similar construction without the joint; the teeth well arranged; price moderate.
2 0 0	37	45	Messrs. Ransome and Sims.	These harrows covered the land well, and, being longer, worked steadily. The same observations apply as are given to No. 47, with a moderate price.
Commended.	76	4	James Comins.	The harrows were well adapted for field-work (except being somewhat too short), and are generally useful. Price moderate.

HEAVY OR DRAG HARROWS.

3 0 0	132	28	Messrs. Howard.	Similar in manufacture to No. 20, having the advantage of double draught-hooks; teeth well arranged; covering the ground well. Price moderate.
2 0 0	103	7	W. Williams.	Very useful pair-horse harrows; worked and covered the land well; wanted an arrangement to prevent the nuts shaking loose.
Highly commended.	37	45	Messrs. Ransome and Sims.	Good and useful harrows, with collared nuts; the workmanship and teeth arrangements very good. These harrows received a premium as general-purpose harrows. The draught-hooks require bending downwards.
Ditto.	78	42	E. H. Bentall.	Good and useful harrows, made of double angle-iron; nuts secured by rivets; having great strength; price in their favour, but wanting the advantage of double draught-hooks.
Favourable mention.	..	..	Coleman.	Expanding harrows: a useful harrow, intended for wide or narrow stetches.

CULTIVATOR, SCARIFIER, OR PARER.

Prizes and Awards.	Stand.	Art.	Exhibitor's Name.	Remarks.
£. s. d.				
				OBS.—In continuing our remarks on field implements, it may be well to observe that many of them have been constructed to accommodate stetches into which both heavy and light land is frequently thrown. Such is the case with Coleman's expanding harrow, and other kinds of jointed harrows tried in the field. We are not, it may be hoped, going beyond the bounds of our jurisdiction, when we state the probability of stetches disappearing before improved implements and improved husbandry. Hence, it may not be necessary to make provision for this kind of land by manufacturing implements expressly for the purpose.—The word *cultivator* implies a general field implement, and may be divided into classes for surface and deeper cultivation.
3 0 0	78	10	E. H. Bentall.	This implement was exhibited in several classes, and performed well in each. The test was most severe both on light and heavy land, and it sustained its reputation as a general-purpose cultivator, while the price is very moderate.
3 0 0	83	9	R. Coleman.	This useful implement was placed in competition with the above (Stand 78, Art. 10), and fully deserves being placed in the same rank. It is easily taken out of the ground while turning, and in this respect may be considered superior to its rival, and it also breaks and more fully pulverises the soil, while it is larger and more expensive.
2 0 0	37	36	Messrs. Ransome and Sims.	A very good implement, and worked steadily and well through the clods. It is on a larger scale than others; the workmanship, and the general arrangement in the details, of a superior class.
Very highly commended.	111	4	H. Carson.	For its useful adaptation to heavy land as a drag and paring implement. The wheels are well arranged, and the iron lever greatly facilitates its turning at the head-lands and in travelling.
Highly commended.	8	6	A. Crosskill.	The Ducie drag, an implement of great power, and steadiness in working heavy land. The arrangement for raising and lowering it is very simple, whether for travel or for adjusting the different working depths as a stubble-parer.

CULTIVATORS ON LIGHT LAND.

3 0 0	83	5	R. Coleman.	This implement worked well under all the difficulties of a dry and parched surface, not only as a deep cultivator, but as a scarifier. It is inexpensive, and a very useful implement, moving and pulverizing the soil.

CULTIVATORS ON LIGHT LAND—*continued.*

Prizes and Awards.	Stand.	Art.	Exhibitor's Name.	Remarks.
£. s. d.				
3 0 0	78	10	E. H. Bentall.	This implement was tried in the class of heavy-land cultivators, and proved itself a most useful implement as a drag and scarifier on light land, at a moderate price. It takes a larger breadth than Coleman's, and does not consequently so thoroughly pulverise the soil.
1 0 0	97	59	Messrs. Phillips and Wood.	A Finlayson drag, or harrow; a most efficient tool on fallow lands; worked well, but not intended for a scarifier in the present form.
Commended.	37	39	Messrs. Ransome and Sims.	A most useful implement for small holdings, with a moderate price; the tines covered the land, and it worked well.
				OBS.—The trial of paring implements was very imperfect, owing to the hard and impenetrable nature of the soil. It will be well to state that, if any implement could bear the test of the Chelmsford trial on the notable clays of Essex, it need not be afraid of the soil of any county in Great Britain.
				SCARIFIER OR PARER.
3 0 0	83	5	R. Coleman.	The same implement tried as a cultivator on light land, to which we refer.
2 0 0	78	10	E. H. Bentall.	This implement tried as a cultivator on light land, and, as before stated, proved well in all the different states of trial to which it was submitted.
Commended.	124	2	Messrs. Hill and Smith.	This implement received a commendation. It is useful as a stubble-parer; cuts all the ground well; not expensive; it would be improved if some arrangement were made to cause the cut surface to lie hollow, and thus DRY better in the autumn.
Favourable mention.	76	1	James Comyns.	A paring plough (Glover's principle). The land too dry to admit of its working; it is, however, under common circumstances, a useful implement on a small farm.
				SUBSOILERS.
5 0 0	78	1	E. H. Bentall.	This implement worked well, and followed the plough smoothly, notwithstanding the hard and dry nature of the subsoil. It is cheap, and has the advantage of a long beam and a long bottom. It thoroughly broke up the subsoil. This implement is a part of the broad share, the sides being taken away, leaving the beam, handles, and centre coulter.
4 0 0	131	5	William Smith.	The tooth of this implement was very strong, and in a proper shape and inclination. It broke up the ground completely, but would be improved, with additional teeth, by a longer beam.
4 0 0	110	33	Messrs. Dray and Co.	A useful subsoil plough (Gray's), broke up the land and thoroughly pulverised it. The implement would work steadier if the spring in the gauge-bar could be prevented.

SUBSOILERS—*continued.*

Prizes and Awards.	Stand.	Art.	Exhibitor's Name.	Remarks.
£. s. d. 3 0 0	132	3	Messrs T. and F. Howard.	This implement is Howard's well-known wrought-iron plough, converted into a very effective subsoiler by removing the ordinary body and attaching the subsoil frame; the extra cost being 20*s.* Total cost 3*l.* 12*s.* 6*d.*
3 0 0	37	28	Messrs. Ransome and Sims.	Subsoiler (A. Beauclerk). This implement worked very well. The screw attached is a novel and curious appendage. If it increases the draught it may be of no use.
1 0 0	50	30	Barrett, Exall, & Co.	A useful subsoil plough on Read's principle.
Silver Medal.	37	32	Messrs. Ransome and Sims.	For a Cotgrave's subsoil and trenching plough. A well-established implement: when tried on Fowler's steam-ploughing system, did its work very well.

CLOD-CRUSHERS—PLAIN, AND SERRATED ROLLERS.

Prizes and Awards.	Stand.	Art.	Exhibitor's Name.	Remarks.
3 0 0	8	3	A. Crosskill.	For a Crosskill's improved clodcrusher having serrated discs moving at different velocities, which gives it a self-cleaning action. The discs are fixed on a round axle, which facilitates its turning. The implement maintained its established reputation.
3 0 0	110	31	William Dray and Co.	An improved serrated roller having discs, to which an eccentric motion is given by the mode of attaching them to the spindle. This gives it a compound action, and self-cleaning is attained. The implement did its work very well.
2 0 0	56	5	W. Cambridge.	A useful general-purpose roller, moving on convex discs. It is well adapted to roll wheat, and as a crusher on fallow lands.
2 0 0	37	3	Messrs. Ransome and Sims.	For a Crosskill's roller, somewhat different in its arrangements to the one exhibited, Stand 8, Art. 3; but a most useful roller.
2 0 0	12	1	W. Day and Co.	A roller having alternating smooth and serrated discs. It worked well, and produced an abrasion of the soil under the serrated discs, while the smooth ones had a crushing effect.
2 0 0	37	55	Messrs. Ransome and Sims.	A most useful plain roller for wheat or fallow lands, in three cylinders, which are independent of each other, and turn round without dragging (slading, or sledging) the land.
2 0 0	124	8	Hill and Smith.	A smooth roller, having wrought-iron plates instead of metal ones. It is the first application of wrought iron to a roller, and its advantages are that a light roller is obtained having a large diameter.
2 0 0	78	40	E. H. Bentall.	A light and smooth roller in two parts, jointed in the middle, and intended chiefly for stetch-work, for which it is well adapted.
Highly commended.	8	5	A. Crosskill.	A Norwegian harrow, or spiked roller; a most useful implement, being an improvement on the old-fashioned spike roller, with the advantage of the spikelets moving on a round axle and independent of each other.

CLOD-CRUSHERS, &c.—*continued.*

Prizes and Awards.	Stand.	Art.	Exhibitor's Name.	Remarks.
£. s. d. Highly commended.	76	7	T. Comins.	A very useful clod-crusher for small occupations, having a double row of serrated discs, which work within each other. This implement works well on a fallow growing couch-grass.
Ditto.	99	1	F. T. Utting.	A combined roller and clod-crusher, having an oscillating action when used without the regulating pin. The first roller is a series of toothed discs; the hind discs are smooth, and work within each other. The object sought to be attained by Mr. Utting in the arrangement of the roller is to make it either a smooth or toothed roller, or both, as required. To do this a semicircular casting is provided at each end, with holes to receive a regulating-pin, the centre of which is the axle. To make it a smooth roller only, which is behind, the serrated one is lifted up, and a portion of the weight necessarily will fall on the horse's back unless prevented by some contrivance not yet provided. If the serrated roller is to be used, the weight of the roller behind is thrown upon it and the bellyband of the horse, excepting so much of the weight as is counterbalanced by the frame and shafts. When both the rollers were let alone to find their own level, they worked well.
Ditto.	111	1	H. Canson.	A useful implement for general purposes as a field roller and crusher. A scraper is provided, which is moveable at pleasure. Worked well on trial, but some improvement has yet to be made in the details.
Ditto.	56	7	W. Cambridge.	A clod-crusher with convex discs moving on a round axle, the bush of the discs being triangular instead of round, causing a peculiar jerking motion, which in some degree prevents its clogging.
Ditto.	42	2	W. L. Fisher.	A roller having three cylinders with projections on the face, with a provision made to apply grease or oil to the inside of the boss. The projections are like a sheep's foot, and intended to represent the treading of that animal.
Ditto.	37	57	Messrs. Ransome and Sims.	A useful roller, intended for barley or light land generally, having three independent cylinders, which work well together, and have the common advantages of rollers made in parts.
Commended.	50	32	Barrett, Exall, and Co.	A serrated roller for general field work, having brass bushes for spindle. Turns and works well.
Ditto.	83	20	R. Coleman.	A smooth disc roller, having a joint to accommodate itself to round stetches. The design is good so long as stetches remain, but some improvements in the details are necessary.

CLOD-CRUSHERS, *&c.—continued.*

Prizes and Awards.	Stand.	Art.	Exhibitor's Name.	Remarks.
£. s. d. Commended.	42	1	W. L. Fisher.	This roller is similar to the one exhibited by Mr. Fisher (No. 2), having sheep-foot projections on the outside of the cylinders, with a contrivance to lubricate the inside of the spindle without removing the cylinders.

Before concluding our Report on the field implements that came under our notice, it may be well to put the question, how far the principle of self-cleaning increases the draught, and which kind of self-cleaning principle increases it the least? The dynamometer might throw some light on this question.

T. CLARKE.
J. JEPHSON ROWLEY.

Amongst the Miscellaneous Class this year, the brick and drain tile machines were appointed for trial. In reporting upon them we can say but little except recording the results brought out by the dynamometer, and comparing them with those of previous years. Indeed every year must be pregnant with more than ordinary efforts of genius to bring even novelty to bear upon so simple a process as tile-making. While admitting the strength, durability, and first-rate workmanship of the machines which come more particularly under our notice, we respectfully venture to express the feeling generally prevalent amongst the purchasers of prize implements, that, whatever may be said of the over plethority of animals exhibited for the Society's prizes, they do not excel the normal excellence prescribed by its rules so much as implements frequently supplied fall short of the standard of those stamped with the Society's approbation.

The pipe and tile machines selected for trial were Scraggs', Clayton's, and Whitehead's. It will be seen that Scraggs' machine consumed less power in screening the clay, but Whitehead's more than compensates for it in making the tiles, so that we considered the latter entitled to our first consideration—whilst the near approach of Mr. Scraggs to every requisite excellence entitles him also to the Society's approbation. We have awarded 5*l*. to Mr. Whitehead, 4*l*. to Mr. Scraggs, and commend Mr. Clayton's machine, considering it superior to horizontal machines for making tiles of large diameter.

Subjoined are the tabular results, in which will be seen a gradual improvement during the last three years—the number of imperfect pipes was so trivial as not to be worth recording:—

PIPE AND TILE MACHINES.

Screening Clay.

	Gross weight of Clay screened.			Tare.			Total Time.		Units of power to do the whole Work.	Units of power to Screen 100 lbs.
	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	min.	sec.		
Scraggs	6	3	0	0	2	4	13	0	39,780	5,262
Clayton	6	3	0	0	2	6	16	0	59,880	8,053
Whitehead ...	6	3	0	0	1	26	11	50	55,880	7,391

Making Tile.

	Net weight of Clay screened.			Time filling Machine.		Time actually at Work.		Number of good Tiles 13¼ in. long.	Total units of Power.	Units of power to make 100 feet of Tile.	Length of Tile made per minute in feet.
	cwt.	qrs.	lbs.	min.	sec.	min.	sec.				
Scraggs ..	6	0	24	1	30	5	0	227	33,550	13,157	51·
Clayton ..	6	0	22	2	30	5	30	193	35,540	16,378	39·6
Whitehead	6	1	2	1	15	4	45	236	30,700	11,541	56·

The annexed trial of Mr. Clayton's brick machine with steam power, which pugged the clay and made perfect bricks at the rate of 2500 per hour at a cost in labour of about 20*d.* per 1000, we consider an element in accomplishing an object the Society has so much at heart, viz. "cheap dwellings for the poor," a desideratum well worthy of every friend of civilized society. We have awarded him a prize of 5*l.*, and must express a high opinion of the effective manner in which his machine did its work; at the same time that we point out the great discrepancy between the actual power employed and that described in the catalogue.

Clayton's Steam Brick Machine.

Forty-two bricks per minute, 12-horse power, five men, four boys; total cost of making about 20*d.* per 1000.

Chamberlain's brick machine we could not put on trial, which we regretted. By some means it got broken while in the yard. There was ample time to replace the broken wheels, which Mr. Chamberlain showed no disposition to do. This we considered somewhat extraordinary conduct, when so much has been written and said of this machine. We must leave the public to draw their own conclusions from it.

The miscellaneous articles exhibited each year are always objects of peculiar interest, inasmuch as they are either appendages to assist in the working out of a system incurred by the employment of machinery for agricultural purposes, or articles of utility by themselves, or they add to the comfort and convenience of domestic life. Taking the catalogue seriatim, our first attention was attracted to the draining tools, for which and the hand tools generally Burgess and Key stand pre-eminent in the show-yard for their handiness and good workmanship. We beg to award them a prize of 3*l.* for the set of draining tools, No. 44.—We next come to Mr. Biggs' sheep-dipping apparatus, but must say that, if there is any profit in cradling the sheep, it is to the vendor of the dipping-composition, &c.; as the quantity of liquid the sheep carry away in their coats, the loss of time in strapping and unstrapping, and the number of times the animal has to be handled, would make a great charge on the fleece.—The gutter tile spouting exhibited by Mr. Lawes is very good, were it not for the high price put upon it.—The skin-fleeces shown by Barry Brothers, to establish the efficacy of Long's dressing, only prove what nice wool might be obtained with great care and attention, provided it would answer; but as there were no corresponding skins shown of sheep kept in the open field with the ordinary care, &c., we can form no comparative opinion of its merits generally, but think we might recommend it to some of the exhibitors of prize sheep in lieu of their own. On the other hand, from 1 lb. to 3 lbs. of wool will not repay the cost of dipping every six weeks, as it certainly may be obtained by dipping twice a year.—Mr. Keevel's patent cheesemaking tub, by Griffiths and Co., is worthy the attention of dairy farmers, as whatever tends to lessen ex-

pence, and at the same time increase the produce and quality of the material, is a great advance on the road to perfection. Looking at the nicety required in the act and the great waste from bad management, we think very favourably of this invention, and have awarded it a medal. The price appears to be high, and will no doubt lessen the sale. With a strong tub and much less expensive gear, it would be equally effective and durable, and might, we think, be sold at a more reasonable price.—As a new invention, the barley-awner of Messrs. Ransome appears the best brought out, which we should have highly commended had we had the opportunity of trying it before our awards were delivered in. After some barley-thrashing in the trial-yard, we put it to the test and found it quite answered our expectation, with less power than these implements generally require.

What to grow, and how to render the produce of the farm available for sale, without decreasing the fertility of the soil, is one of the great problems to be solved by the farmer. The growth of flax appears to be one of the subjects tending to accomplish this end, but hitherto the sale of the straw has prevented the profitable cultivation of the plant. Mr. Pye appears to have hit upon an invention to render the fibre more valuable after the seed has ripened. The specimens produced appeared but little depreciated compared with green straw; should this desirable end be obtained very many acres of clay land might be profitably cropped with flax, instead of fallow, as the short time required for maturing the plant would leave ample scope for a good fallow afterwards, and the seed would very much assist in fattening stock in combination with the root crops. We have awarded Mr. Pye a medal for his method of preparation, wishing the project every success.

The patent endless band saw of Messrs. Barrett, Exall, and Andrewes, is a new feature in cutting timber when it is required to be cut in a curve, such, for instance, as felloes of wheels, &c.; the friction is much less than in the circular saw, and it seems to us a very desirable machine for the workshop. We awarded it a medal.—A patent corn and malt screen, exhibited by R. Boby, worked by a crank, the screen parts fitted with rollers between each wire, preventing the possibility of blocking up, and giving free egress to the thin kernels, thereby separating the grain and making a fine sample, we consider a great improvement over the old plan, and have awarded him a medal.—Perhaps the most lamentable specimens of mechanical necessity are corn-dressing machines like Mr. Hackvale's, with special contrivances to take out the seeds of weeds from corn; but so long as the notion is entertained that weeds indigenous to particular soils are bred like tadpoles in a horse-pond, we suppose we must continue to recommend them to the notice of slovenly farmers.—The variety of root-mincers or pulpers by Phillips, Bentall, Barnard, and Bishop, are all improved since last year; still the work appears to us to be best done by Phillips at present. Having paid great attention to this system of feeding for these last two years, we may be excused for digressing a little while speaking of these machines. Roots require to be cut into very small crystal-like pieces, then mixed with two-thirds chaff, allowed to ferment, the time depending on the temperature of the weather; by no means let it sour; if for fat cattle mix corn or cake with it; if for store stock, bran, pollard, malt-dust, &c. This plan is the most economical and profitable way of keeping milking cows or lean stock through the winter. The butter is of good quality, and quite free from the disagreeable flavour which often follows when roots are given to them. —There was the usual variety of miscellaneous articles that make up the total of the show-yard, such as Read's patent watering-engine and double-action green-house pump; garden-tools, watering-pots, housemaid's barrows, and numerous horticultural appliances by Gidney and Son; lawn mowing-machines by A. Shanks and Co.; circular iron corn-bins, well adapted for riding-stables; washing and wringing machines; a portable farm forge, ex-

hibited by Dray and Co.; together with their tubular field-gates and the rick-stands of Hill and Smith, both of which we commended.

We cannot close these remarks without expressing our thanks to Mr. Amos, and more particularly to his assistant, Mr. Coombs, who effectually assisted us in our duties.

THOS. HAWKINS.
JAMES HALL NALDER.

TRIAL OF FIELD IMPLEMENTS.

Report on Ploughs.

The sum of forty sovereigns was offered by the Society in prizes for the class of ploughs generally, not as in former years in the shape of a single prize for the best plough, but at the discretion of the Judges for apportionment to the several competitors in proportion to their respective merits.

The Judges divided the ploughs selected for trial into five classes, and apportioned the prizes in each class as follows, viz.:—

1. For the ploughs best adapted to general purposes ..	£15
2. For the ploughs best adapted to heavy land	10
3. For the ploughs best adapted to light land	10
4. For the best ridge plough	3
5. For the best turnwrest plough	2
	40

Ploughs for General Purposes.—Eight ploughs were selected for trial in this class, two of which were local ploughs, constructed partly of wood, belonging to Mr. Bentall and Mr. Warren of Maldon; and the remaining six were iron ploughs belonging to Messrs. Ransomes and Sims, Howard, Ball, Busby, Carson, and Fry. All the ploughs, except Mr. Warren's, were fitted with wheels.

Two series of experiments were made in this class, first on a freeworking and rather light loamy soil; and next upon a field of pastured seeds, on soil naturally strong, but rendered stronger by the treading of stock, and unusually hard from the dryness of the weather.

It was arranged that each plough should commence with a furrow of 9 inches by 6, to be gradually increased to a depth of 7 inches by 10, that the draught of each plough should then be tested by the improved dynamometer specially manufactured for the Society by Mr. Amos, and which was used on this occasion for the first time with most satisfactory results.

In the light land the work was generally well done by all the ploughs, though even here the advantage of the iron wheel ploughs was very obvious, and the work produced by Messrs. Howard's plough in particular exhibited a marked superiority.

It was, however, in the strong land that the capabilities of the several implements were worthily tested, and none but ploughs of the best construction had the smallest chance of success. Notwithstanding the difficulties arising from the heavy texture and extreme hardness of the ground, much of the work was well done, and though, during the progress of the trials, the competition was occasionally very close, and the merits of several ploughs sometimes pretty evenly balanced, yet the performance of Messrs. Howard's plough was upon the whole such as clearly to entitle it to be placed the first in its class. The Judges awarded the sum of 15*l.* in the proportions which in their opinion indicate the comparative merit of the several ploughs, viz.:—

To Messrs. J. and F. Howard, of Bedford, the sum of ..	£7
„ Mr. Ball, of Rothwell, near Kettering	4
„ Mr. Bentall, of Heybridge, near Maldon	4

In estimating the comparative merit of ploughs, next in importance to the quality of work produced is the power required for their traction. The Judges of the Society have always had their attention directed to this point, but, owing to the imperfect dynamometers hitherto in use, the results have been rough average approximations rather than exact quantities. The trials of the present year have been made with a new dynamometer constructed by Mr. Amos on similar principles to those used at the Society's Meetings for measuring the power of steam-engines, and which records with the greatest precision the exact force exerted in the traction of a plough at every step in the experiment.

The following Table gives the result of the trials:—

Exhibitors' Names.	Stand.	Article.	Dimension of Furrow-slice.	Force of Traction.	Price.
			in. in.		£. s. d.
Warren	133	4	10 × 7	1367	2 13 0
Ransomes and Sims ..	37	2	10 × 7	1383	4 17 6
Bentall	78	16	10 × 7	1410	3 13 6
Ball	74	1	10 × 7	1413	4 14 6
Howard..	132	1	10 × 7	1435	4 18 0
Busby	20	6	10 × 7	1685	4 17 6
Carson	111	7	10 × 7	1759	4 5 0
Fry	13	3	10 × 7	1943	5 10 0

Ploughs best adapted to Heavy Land.—This trial was upon a field of seeds pastured, on a strong heavy soil, very hard and dry, in such a state that few farmers would have attempted to plough it, and in which none but the best ploughs could possibly work.

Five ploughs competed in this class; the names of the competitors and the results are given in the subjoined Table.

The conditions were that the furrow should be 8 inches deep by 10 wide; the turf to be pared and deposited under the furrow.

The quality of the work done by most of the ploughs was admirable. Notwithstanding the unfavourable condition of the ground, the furrow was cut with great cleanness and regularity; the turf was pared, turned, and deposited with facility and completeness; and the result of this trial afforded a striking proof how ample and complete is the control which our best constructed ploughs now give over the most stubborn soils in the country.

Exhibitors' Names.	Stand.	Article.	Dimensions of Furrow-slice.	Force of Traction.	Price.
			in. in.		£. s. d.
Ball	74	2	10 × 8	2289	5 10 0
Busby	20	5	10 × 8	2804	5 12 6
Howard..	132	10	10 × 8	2215	6 0 0
Ransomes and Sims ..	37	7	10 × 8	2985	5 17 6
Warren	133	10	10 × 8	1815	4 4 0

The Judges awarded the 10*l.* appropriated to this class as follows, viz.:—

To Messrs. J. and F. Howard, the sum of £5
,, Mr. Ball 3
,, Messrs. Ransomes and Sims 2

Ploughs best adapted to Light Land.—Seven ploughs competed in this class,

which were tried upon a field of light loamy soil, in most favourable condition for exhibiting excellence of work. A furrow 7 inches by 9 was the condition proposed, at which depth the dynamometer was applied. The work of the entire class, excepting Mr. Carson's plough, was excellent, and the competition unusually severe. So evenly balanced were the merits of Messrs. Ransome, Ball, and Bentall, that no distinction could be made, and the Judges awarded to them an equal prize; but the superior work by Messrs. Howard's plough, combined with its lightness of draught, induced the Judges to award to them the highest prize.

The following is the result of the trials:—

Exhibitors' Names.	Stand.	Article.	Dimensions of Furrow-slice.	Force of Traction.	Price.
			in. in.		£. s. d.
Ball	74	3	7 × 9	1400	4 8 0
Bentall	78	15	7 × 9	1444	3 10 0
Busby	20	7	7 × 9	1470	4 7 6
Carson	111	6	7 × 9	Discontinued work before Trial was completed.	
Fry	13	2	7 × 9	1330	4 15 0
Howard	132	3	7 × 9	1100	3 12 6
Ransomes and Sims ..	37	4	7 × 9	1225	4 7 6

The Judges awarded the sum of 10*l.* apportioned to this class as follows, viz.:—

To Messrs. J. and F. Howard	£4
„ Messrs. Ransomes and Sims	2
„ Mr. Ball	2
„ Mr. Bentall	2

Ridge Ploughs.—Messrs. Howard and Ransome were the only competitors in this class, and the Judges awarded the prize of 3*l.* to Messrs. Howard.

Turnwrest Ploughs.—Five ploughs belonging to Messrs. Ransome, Howard, Bentall, Comins, and Coleman, were selected for trial, and the prize of 2*l.* was awarded to Messrs. Ransomes and Sims for their turnwrest plough, "Lowcock's Patent," stand 37, article 22, price 6*l.* 17*s.* 6*d.*

Upon the whole the Judges are of opinion that these experiments have exhibited ploughing fully equal in merit to what has been seen at any former meeting of the Society; and though no striking novelty has been introduced in the construction of ploughs, yet some minor improvements have been made tending to the perfection of these important implements.

It is a peculiarity of English agriculture that ploughing is an operation of greater difficulty in England than on the continent. Besides the greater natural tenacity of the soil, arising in part from the greater humidity of the climate, the alternation of grass and corn crops, and the amount of stock depastured upon the land, all give to our arable fields an unusual degree of solidity, while the growth of artificial grasses renders a complete inversion of the soil an absolute necessity. Those who witnessed the trials of the ploughs at the Paris Exhibition will have seen the widely different conditions of ploughing in England and France, and how completely the improved construction of our English ploughs is fitted to cope with the special difficulties of English farming. In proportion to the difficulty of the operation is the necessity of having good instruments, and the most useful lessons inculcated by the trials at Chelmsford appear to the Judges to be, that they establish the importance of solidity and strength in the construction of ploughs, and demonstrate the decided superiority of the iron ploughs with wheels to the wood ploughs without wheels, still too extensively in use.

To those who have watched the experiments at the successive meetings of the Society these will appear very common and familiar truths, but it is impossible to travel far in any direction without seeing that they are unknown or unappreciated by vast numbers to whom such knowledge would be an important benefit. To diffuse this knowledge and extend the use of our best implements is one of the special objects of the Society, and there is perhaps no better mode of quickening the process than by such exhibitions and trials as are here recorded.

Water-drop Drill.

This is one of the few implements exhibited which can lay claim to the title of an entirely new and at the same time most useful invention. The drill, though exhibited by Messrs. Garrett and Sons, is the invention of Mr. Thomas Chambers, a tenant farmer in Norfolk, honourably known as the inventor of the best manure distributor. On the propriety of subjecting this invention to trial there appeared some diversity of opinion among the officers of the Society, as the class of drills will be tested in due course next year. The Judges unanimously decided that the water-drop drill was essentially a new implement, and could, therefore, compete for a special prize offered by the Society for such novelties.

Mr. Chambers' invention is confined entirely to the coulter, which can readily be applied to any water-drill now used. The drop is effected in an extremely simple and efficient manner, and cannot fail to increase the reputation which Mr. Chambers has deservedly established by the invention of his manure distributor. The water, seed, and manure are passed into a hollow iron wheel, which revolves. This wheel is furnished with three orifices, so that at each revolution three bunches are dropped.

The principle of a drop drill has often been advocated as economising manure and seed, by placing them only where they are wanted. But dropping the seed with any dusty manure lessened the chance of its germinating in dry weather. This objection is obviated by the application of water, and as the water is dropped in one spot instead of being distributed in a continuous stream, sufficient moisture can be given to cause the seed to vegetate in the driest season. After an interesting trial the success of the implement was fully established, and the Judges had much pleasure in recommending the Council to bestow a prize of 5*l.* on the invention. They regretted that no mention of this award was made in the prize list published by the Society, and that no placard was issued to Mr. Chambers by which his success could be made public in the show-yard.

Reaping Machines.

The trial of these machines at Chelmsford constituted, as in former years, one of the most attractive features of the Society's show.

A large attendance of agriculturists from all parts of England, in addition to many from the continent, attested the interest which is felt in the progress of these machines, and the importance of securing so valuable a substitute for human labour in the critical and urgent labours of the harvest.

Four machines were submitted for trial upon a standing crop of rye, which, as it presented no sort of difficulty, so it afforded no adequate test of the comparative merit of the several machines.

These trials early in July, upon crops so unlike those for which reapers are required, have long been felt to furnish most inadequate data for judging of their merits; and after the careful and extended trials last year so liberally afforded by Mr. Miles, at Leigh Court, the Judges were unwilling to disturb the result of those trials upon an experiment so limited and unsatisfactory as was afforded them at Chelmsford. These circumstances being represented to the Stewards, it was decided to send the machines for a further trial upon Mr. Fisher Hobbs' estate at Boxted Lodge, near Colchester.

The following machines were selected:—

Bell's improved machine, exhibited by Crosskill, price 42*l*.
Hussey's reaping machine, exhibited by W. Dray and Co., price 25*l*.
M'Cormick's machine, exhibited by Burgess and Key, price 40*l*.
Forbush and Co.'s reaper, improved and exhibited by John Palmer, price 32*l*.

Trials at Boxted Lodge.

The trials of reapers were resumed at Boxted Lodge on the 13th and 14th of August.

Two fields of wheat, one a heavy and partially laid crop, on a well-drained and flat surface, the other a lighter and standing crop of wheat, on ridge and furrow, both perfectly free from all couch and weeds; and a field of oats consisting of a strong, partly standing and partly lodged crop, were the fields selected for trial. Every variety of crop which a varied and extensive farm could supply, an unlimited command of horse and manual labour, and every facility which could be given for insuring a satisfactory trial were provided most liberally by Mr. Hobbs. For the greater part of two days, favoured by the finest weather, these machines were successively tried in wheat standing and lodged, on level surfaces and over ridge and furrow; on oats both standing and lodged, and in such variety of situation and circumstance as appeared best calculated to exhibit their respective merits.

As none of these machines, with the exception of Crosskill's, which will be specially mentioned hereafter, have undergone any important change in their construction since last year, to describe them in detail would be merely a repetition of last year's Report; the Judges therefore content themselves with saying that, excepting Crosskill's machine, they are all substantially what they were last year, and since then no improvement whatever has been made.

The machines having been submitted to various trials, in which all were found capable of cutting and delivering ordinary crops of corn, at least as perfectly and economically as the mower's scythe, a standing crop of wheat of great strength and bulk was set out in plots for each machine, in which the quality of work and the time of performance were the conditions of competition.

The following was the result:—

Name of Exhibitor.	Time at Work.		Quantity Reaped.		
	h.	min.	a.	r.	p.
W. Dray and Co. ..	1	40	1	2	27
A. Crosskill	2	5	1	2	23
Burgess and Key ..	1	53	1	1	16

The sum of 50*l*. was offered by the Society for the class of reaping machines, and of this sum the Judges awarded to Alfred Crosskill, for the best reaping machine for general harvest purposes, 20*l*.

To William Dray, for the best reaping machine for wheat crops, 15*l*.

To Messrs. Burgess and Key, for their reaping machine for general purposes, 15*l*.

The reaping machine belonging to Mr. John Palmer, owing to the non-attendance of the owner, was not put in competition.

In the trials at Leigh Court last year, the first prize was given to Messrs. Burgess and Key, though Mr. Crosskill was then a competitor with Bell's machine. As the trials at Boxted have led the Judges to give Mr. Crosskill the first prize, it seems desirable that the grounds of this change of position should be stated.

The machine of Messrs. Burgess and Key has undergone no improvement since last year, but Mr. Crosskill has improved his machine.

There have always been some points of excellence in Bell's machine not

shared by any other. The power of cutting in any direction, of delivering the corn on either side, right or left, and of requiring no scytheman to prepare its way, are advantages peculiar to this machine.

These have hitherto been considered as counterbalanced by the excessive draught of the machine, by the liability of the delivery-web to become disordered, and by the labour and difficulty of steerage. These drawbacks have since last year been in a considerable degree removed. The delivery-web has been superseded by three gutta-percha bands, which, without detracting from its former efficient delivery, has reduced friction and greatly diminished draught. Other minor alterations have been made still further diminishing draught.

These improvements, in connexion with the actual performance of the machine at Boxted, the Judges believe fully justify their award, and place this implement the first in its class.

In awarding a prize to Dray and Co.'s machine as the best reaper for wheat crops, the Judges would observe that this machine has few points in common with the other machines. Dray's machine is strictly a *reaping* machine, and in practice must be limited to such crops as can be immediately bound. The others are really *mowing* machines, and have a wider application. As a reaper the Judges consider Mr. Dray's the best machine, and that it can be economically used is evident from the Boxted trials. In 1 hr. 40 min. it cut extremely clean and well 1A. 2R. 27P. of a strong wheat crop, and with two men with the machine and six men to tie, the whole crop was set up in three minutes after the corn was cut. This will give in all eight hands, at a cost of say *1l.* 17*s.* per day, and at the rate above given the quantity cut in twelve hours would be 11A. 3R. 9P. This is far superior to any result from manual labour.

Although the Judges cannot help repeating the expression of their regret that very little improvement has been made in these machines during the past year, they are nevertheless of opinion that in their present state they may in many districts be used with great advantage and economy; and they entertain no doubt that in a short time they will come into general use, and meet all reasonable requirements.

Steam Cultivation.

A prize of 500*l.* was offered by the Society for the "Steam cultivator, that shall in the most efficient manner turn over the soil, and be an economical substitute for the plough or the spade."

The trials of the steam cultivators formed unquestionably the chief feature of this year's exhibition, and will doubtless mark an important era in the history of the Society.

There seems now no reason to doubt that the cultivation of land by the mighty agency of steam will be accomplished, that what has hitherto been regarded as the fond dream of theorists will become a reality, and that agriculture will be rescued from the reproach that it has been unable to use in its daily operations an agency which has been such an element of power and prosperity to all other industries.

Two cultivators, differing considerably in their character and mode of operation, one belonging to Mr. Smith of Woolston, the other to Mr. Fowler, were exhibited for competition. Mr. Smith's apparatus consists of a common 7-horse portable steam-engine, and a stationary windlass fixed in the corner of a field. A couple of ½-inch wire ropes are led from the 2 drums on the windlass, in opposite directions round 4 anchored pulleys, and meet at the cultivating implement, thus passing round the field; 2 anchors being fixed, and 2 shifted from time to time along each headland as the work proceeds. Mr. Smith uses cultivators or grubbers of a peculiar kind, taking a breadth of about 3 feet at a time, and he has an ingenious mode of turning them quickly at the end of the furrows. He does not attempt to plough or invert the soil, but scarifies or baulks it: about 4 acres is the work of 12 hours, and the cost, including wear and

tear, interest of capital, and all expenses, amounts to about 8*s*. per acre. There is much to commend in the ingenuity and simplicity of Mr. Smith's arrangements, and he has no doubt done much in showing the mode of applying steam to the traction of field implements. Mr. Smith does not invert the land, he says his system of cultivation does not require it, and he does not think that inversion of the soil is of much moment. There can, however, be no difficulty in attaching ploughs to Mr. Smith's traction-ropes by those who prefer them.

The Judges think Mr. Smith mistaken in not aiming at complete inversion of the soil, but, however that may be, the condition of the prize is that the implement shall "*turn over the soil*," and as this is contrary to Mr. Smith's present system, the Judges can only report that, in their opinion, Mr. Smith's present cultivators do not conform to the conditions on which the Society's prize is offered.

Mr. Fowler's arrangements consist of a portable double cylinder engine, driving a capstan by a short endless chain, and stationed half way down one side of the field. Two wire ropes are led from the drum across the field direct to the two ends of the work, then passing round two anchored pulleys and meeting at the implement. The anchors are most ingenious, and consist of two trucks filled with earth, with sharp cutting discs for wheels which cut into the land, and, though easily moved forward along the headland, present great lateral resistance towards the engine. The implement of cultivation is a frame of wood to which 8 ploughs are attached, 4 working at once, and 4 pointed in the opposite direction for the return. The work of common ploughing, both on light and heavy land, was extremely well done, and two subsoil-ploughs were drawn with great steadiness through the strongest land at a depth of 10 inches, which on trial required the power of 10 horses to pull them. The Judges, in common they believe with every one who saw the operation, were quite satisfied that ploughing could be done in the best manner by Mr. Fowler's machine, and on clay land with the important advantage of avoiding the injurious effects from the tread of horses.

The only question was whether the machine was an economical substitute for the plough, and to arrive at some conclusion on this point a further trial was agreed to be made at Boxted Lodge.

On the 14th of August a long and careful trial took place on a field of wheat stubble on Mr. Hobbs' estate, in the presence of the Judges of the Society, Mr. Amos the engineer, Mr. Brandreth Gibbs, and a great number of spectators. The ploughing was again admirably done, fully equal in regularity and precision to anything that could be done by horse labour. To estimate the cost of the operation was a work of great care and time, and Mr. Amos has given the result in the table which is subjoined.

By this table the money cost of ploughing is shown to be 7*s*. 2¼*d*. per acre. The Judges are of opinion that the cost of the like work by horse power would be at least 7*s*. per acre, leaving the cost of the two processes almost identical.

Under these circumstances, although the Judges cannot say that the conditions of the prize are fully met, yet the improvement effected is so great, and the prospect of early and complete success so probable, that they specially recommend Mr. Fowler's apparatus to the favourable notice of the Council, in consideration of the skill he has displayed, the labour and expense incurred, and the degree of success he has so honourably achieved.

In closing this Report, the Judges desire to express their thanks to Mr. Hobbs, for the facilities so kindly afforded by him in the course of these trials; and for his liberal hospitality and obliging consideration to themselves, and all engaged in these experiments.

THOS. HUSKINSON. H. B. CALDWELL. CLARE SEWELL READ. WM. CHALCRAFT.	*Judges of Field Implements.*

Experiments on Steam Ploughs, with Fowler's Plough, at Boxted Lodge, August, 1856.

Length of furrow .. .. 506 yards.
Width of land taken by the plough (carrying 4 shares) .. $1\frac{1}{3}$ „

No. of Experiment.	Time of Starting.			Time of Stopping.			Time at Work.			Time shifting Anchors, &c.			Power taken as expressed by Revolutions of Counter.
	h.	m.	sec.	h.	m.	sec.	h.	m.	sec.	h.	m.	sec.	
1	1	20	0	1	26	52	0	6	52	0	3	5	177·12
2	1	29	57	1	36	25	0	6	28	0	2	17	177·95
3	1	50	54	1	57	28	0	6	34	0	1	57	171·82
4	1	59	25	2	5	35	0	6	10	0	2	35	175·3
5	2	8	10	2	14	5	0	5	55	0	1	39	161·12
6	2	15	44	2	21	58	0	6	14	0	3	12	190·65
7	2	25	10	2	30	55	0	5	45	0	1	26	172·35
8	2	32	21	2	38	21	0	6	0		..		191·63
							0	49	58	0	16	11	1417·94

	h.	m.	sec.	
Commenced experiments	1	20	0	P.M.
Finished do.	2	38	21	,,
Time lost in lacing straps of dynamometer	0	12	12	,,
(This occurred in experiment No. 2.)				
Time expended solely in experiments	1	6	9	

Time the plough moved .. .. 49·58
Time taken to shift anchors, &c. .. .. 16·11
Quantity of land ploughed per hour, 3 rood 1 p. 4 yd. = ·842 acre.
Power taken. Average .. .. 21·28 horse.

COST PER ACRE.

Cost of Coal.—The consumption of coals, taking the average of the engines tried at Carlisle in 1855, was 5·719 lbs. per horse per hour, and 4 lb. per horse getting up steam. Hence

$$\overbrace{\underset{\text{H.-p.}}{21\cdot28}\times\underset{\text{hours.}}{10}\times\underset{\text{lbs.}}{5\cdot719}}+\overbrace{\underset{\text{H.-p.}}{21\cdot28}\times\underset{\text{lbs.}}{4}}=\underset{\text{lbs.}}{1302}=\underset{\text{cwt. qr. lbs.}}{11\ \ 2\ \ 14},$$

say at 20*s.* per ton, will cost 11*s.* $7\frac{1}{2}$*d.* or $139\frac{1}{2}$*d.* for 10 hours working and getting up steam, ploughing 8·42 acres in that time .. .. = *d.* 16·56 per acre.

Labour and Oil.—Engineer at 4*s.* per day, 4 men assistants at 2*s.* each, 1 boy 1*s.*, oil, &c., 1*s.*.. .. .. 19·95 ,,

Water.—2 horses at 10*s.*; 2 boys 2*s.* .. .. 17·1 ,,

Interest and Wear and Tear.—A farm of 600 acres arable has 1000 to be ploughed annually. Cost of machinery 550*l.*, at 15 per cent. interest, and wear and tear, 82*l.* 10*s.* = 1*s.* $7\frac{3}{4}$*d.* 19·75 ,,

	s.	d.		
Removal, say once for 16 *acres.*—4 horses, 1 man, ½ day	11	0		
Engineer and staff ..	6	6		
	17	6	=	13·125 ,,
(Size of fields averaging 16 acres)				86·485

= 7*s.* $2\frac{1}{2}$*d.* per acre nearly.

Sept. 1*st*, 1856.

C. E. AMOS.

XXII.—*On the Growth of Wheat by the Lois Weedon System, on the Rothamsted Soil.* By J. B. Lawes, F.R.S., F.C.S., and Dr. J. H. Gilbert, F.C.S.

In the year 1849, when wheat was selling at 5*s.* per bushel, and the "*Stout British Farmer*" was complaining of the badness of the times, and felt somewhat perplexed how to pay his rent and retain a little surplus, there appeared a pamphlet entitled '*A Word in Season*,' in which the author explained his method of growing wheat year after year without manure; and he promised to those who would adopt his system and follow his directions, a profit of 4*l.*, 5*l.*, or 6*l.* per acre. Of the numerous essays which have been published on agricultural subjects of late years, few have attracted more attention than this. Commencing its career in 1849 as a pamphlet of less than twenty pages, it has since gone through edition after edition, until now, in 1856, we find the subject much extended, and presented as a book of 120 pages.

In this little book, entitled '*Lois Weedon Husbandry*,' the author, the Rev. S. Smith, goes into considerable detail not before given, as to his mode of growing root and other green crops. But confining attention for the present to *wheat*, it may be observed, that although Mr. Smith has from time to time made various important alterations in the detail of the operations by which his system is to be carried out, he has in no way deviated from his original principle of growing this crop year after year in the same field; the land being subdivided into alternate strips of crop and fallow, the portion cropped one year being fallowed the next, and so on. A great number of intelligent agriculturists have visited the Lois Weedon farm, and, after an inspection of the crops growing on the plans there adopted, have generally been satisfied that the produce has been what the published accounts had stated it to be. Yet it is somewhat singular that those who have endeavoured to follow the directions given, on other soils, have generally been unsuccessful.

The object of the present paper is to give an account of some experiments which have been in progress for several seasons past, with a view of testing the applicability to the Rothamsted soil of the system described in '*A Word in Season*.' And besides discussing the experiments themselves, we propose to consider some points of interest which the principle of the Lois Weedon system involves; for although doubts may be entertained by practical men as to the possibility of cultivating large farms on such a plan, it must still be admitted that the results which have been obtained by the Rev. Mr. Smith himself, are calculated to impress upon us most important lessons regarding the rationale of admitted agri-

cultural facts and practices. They teach us, too, how great, in certain kinds of soil, must be at once the inherent wealth and the power of accumulation and of yielding up to the growing crop the constituents upon which it feeds.

In the year 1851 about three acres were selected for our purpose, in a field adjoining that which has been devoted for so many years to the continuous growth of wheat with and without artificial or other manures. The soil of these fields is a heavy loam, with a subsoil of stiff reddish yellow clay, which rests upon chalk. The depth from the surface to the chalk is perhaps never less than six or seven feet, and frequently twice as much; the natural drainage is, however, good. These soils, without being of high, are still of good average quality, and capable of growing good wheat crops. They are well suited, therefore, to test the degree of applicability to other soils, of plans proposed for extensive adoption in the cultivation of that crop. The field selected was under wheat in 1850, and was a bare fallow in 1851, prior to commencing the Lois Weedon operations in the autumn of that year. For the first crop the land was ploughed and harrowed in the ordinary way, and then set out in three feet strips; of these, every other one was sown with three rows of wheat a foot apart, and the intermediate ones were left as *fallow spaces*, to be prepared for the second year's crop during the growth of the first. It will be seen, that, as each strip was three feet wide, and as the three rows at a foot apart would only occupy two feet, there were in fact *four*-feet fallow spaces, as is recommended by Mr. Smith in some cases, instead of only three, as adopted in his own practice.

The first sowing was in September 1851, and, not having the special implements since recommended for carrying out the plan on the large scale, the seed was *dibbled* in, at a distance of two to three inches apart in the rows. One portion of the experimental ground had a single seed dropped into each hole, thus conforming, as far as possible, to Mr. Smith's mode of sowing single seeds at two to three inches apart in lines made with his presser; another and larger portion of the plot had two seeds in each hole. It was found that the *one-seed portion* took little more than half a peck of seed per acre, that is, half a peck to the moiety of the acre seeded at one time. The Rev. Mr. Smith, however, seems always to have calculated upon two pecks of seed being used, even though sown, as above described, in single grains, at two to three inches apart in the rows. And although, where we sowed two seeds in each hole, or twice as much as is recommended, we got on little more than a peck to the acre, yet it is but justice to Mr. Smith to state, that he now finds a more liberal seeding necessary for safety and security from blight, to which, as will afterwards be seen, our produce obtained on this plan was so subject.

It may here be further mentioned, that not having the special implements—the "*presser implement*," the *drill* "*to drop seed by seed into the hard channels*," the "*roller implement*," the "*horse-hoe implement*," and the "*scarifier and harrow implement*"—which are recommended in Mr. Smith's later editions for carrying out his plan on an extensive scale, we were obliged to adopt his *earlier* methods, by which, however, his records show, that he obtained as good, if not as economical results, as by his later ones.

Before the adaptation of special implements, Mr. Smith's plan comprised "one double digging," "two single diggings, with fork," "pressing, sowing, hoeing," &c.

The following is a concise statement of the operations carried out at Rothamsted, for each of the four crops respectively, which have been obtained in the course of this experiment. And it may here be premised, that one of the three acres was, for the sake of comparison, set apart for alternate wheat and summer fallow—the fallow being cultivated according to the common custom of the neighbourhood.

For First Crop, 1851-2:—

Wheat, harvest 1850; summer fallow 1851; ploughed, harrowed, &c., in the ordinary way, and sown with *one seed*, and *two seeds*, as above described, September 1851; hand-hoed twice, and weeded as other crops. Crop foul, poor, and much blighted; cut in August 1852.

Common fallow acre all sown autumn 1851; seed drilled at the rate of about two bushels per acre, in rows 9 inches apart; hoed and weeded as usual. Crop heavy, but somewhat blighted.

For Second Crop, 1852-3:—

The fallow intervals, which were not sown, trenched 14 to 15 inches in December 1851; forked in spring, and again before sowing; occasionally spudded, but became foul and crusted over during the summer. Seed sown as for first crop, October 1852; hoed twice, and weeded as usual. Crop not clean, poor, and blighted; cut September 1853.

Common fallow acre, all fallow in 1852-3.

For Third Crop, 1853-4:—

Stubble of harvest 1852, trenched 14 to 15 inches December 1852; forked in the spring; spudded occasionally, and again forked before sowing. Sown as above, October 1853; hoed twice, and weeded as usual. Crop pretty clean, but poor, and blighted; cut September 1854.

Common fallow acre all drilled, as before; hoed and weeded as usual. Crop very heavy, somewhat blighted.

For Fourth Crop, 1854-5:—

Stubble of harvest 1853, trenched 14 to 15 inches in winter

1853; forked in the spring; occasionally spudded, and scarified before sowing. Seed sown as usual, September 1854; twice hoed, and weeded as usual; moulded up with the plough in June. Crop clean, but poor, and blighted: cut September 1855.

Half only, of common fallow acre, drilled as usual for season 1854-5; hoed and weeded as usual. Crop small, but much less blighted than before.

In the following Table (I.) are given the results—

Of the four years' trial of the Lois Weedon plan; one portion with "*one seed*," and another with "*two seeds*," in each hole.

Of the "*common fallow*" acre, drilled with about two bushels of seed per acre.

And, for the sake of comparison, the produce in each of the four years, of the continuously unmanured and continuously cropped portion, in the adjoining experimental field.

This Table (I.) shows, that in each of the four years a larger crop was obtained where *two seeds* were sown in each hole than where *one* only was sown; and a reference to the weight per bushel, proportion of offal corn, and proportion of corn to straw, will show that the "*two-seed*" crop was also invariably somewhat better as to quality. As before observed, however, it is only due to the Rev. Mr. Smith to say, that "*for the sake of the sample and for safety sake*," he now recommends the seed to be sown thicker than he did formerly; though even in the later editions of the '*Word in Season*,' he still advised that the seed should be dropped singly, at two to three inches apart in the rows. But, even with the *two seeds*, the crop is in every case quite insignificant; and it should be noticed that it is only in the first year—that is, before the subsoil was brought up—that this thin dibbled crop was larger than the comparatively thickly drilled one on the continuously cropped and continuously unmanured plot in the adjoining field. Further, comparing the best of the two, namely the *two-seed* crop, with the drilled one after common fallow, we find that the latter in each year gives from twice to thrice the amount of produce of the former.

With regard to the drilled crop on the common fallow, it should be remarked that, in the first season (1851-2), the whole acre was sown; in the second season the whole acre was fallow; and in the third the whole was again sown. But, as this plan only gave a crop for comparison every other year, the plot was divided into two portions after the harvest of 1854, which were to be cropped or fallowed alternately. Comparing together the produce of this *common fallow portion*, with that of the *continuously unmanured plot* in the adjoining field, we see that, in 1852, the common fallow gives nearly three times the most produce; in 1854 it gives rather

TABLE I.—Results of Experiments on the Growth of Wheat at Rothamsted, on the Lois Weedon, compared with other Systems. Harvests 1852, 1853, 1854, and 1855.

Seasons.	Description of Plots, &c.		Particulars of Quantity.					Particulars of Quality.		
			Dressed Corn per acre in Bushels, Pecks, &c.	Dressed Corn per acre in lbs.	Offal Corn per acre in lbs.	Straw, Chaff, &c. per acre in lbs.	Total Produce per acre in lbs.	Weight per Bushel in lbs. and tenths.	Proportion of Offal Corn to Dressed as 100.	Proportion of Corn to 100 Straw.
1851-2.	1 First Year (after Common Fallow)	"One seed"	10 0½	515	185½	1866	2516	51·0	26·3	34·8
	2 First Year (after Common Fallow)	"Two seeds" ..	15 2½	795	175	2309	3279	51·0	22·6	42·1
	3 First Year (after Common Fallow)	Drilled	37 0	1901	187	4934	7022	53·0	9·8	42·3
	Adjoining Experimental Field	Continuously unmanured ..	13 3½	782	77¾	1597	2457	56·6	9·9	53·9
1852-3.	1 Trenched, Forked, &c.	"One seed"	4 0¼	211	48½	796	1055	52·0	20·6	32·0
	2 Trenched, Forked, &c.	"Two seeds" ..	5 1	275	46¼	941	1262	52·6	17·5	34·5
	3 Common Fallow	(No crop)	..	..	..	..	..	..	..	..
	Adjoining Experimental Field	Continuously unmanured ..	5 3½	266	93	1413	1772	45·9	35·0	25·4
1853-4.	1 Trenched, Forked, &c.	"One seed"	11 1	661	56	1078	1795	58·6	8·5	66·5
	2 Trenched, Forked, &c.	"Two seeds"	14 2¼	868	48	1368	2284	59·5	5·5	67·0
	3 Common Fallow	Drilled	42 0	2541	168	4545	7254	60·5	6·6	59·6
	Adjoining Experimental Field	Continuously unmanured ..	21 0¼	1277	82	2137	3496	60·6	6·4	63·6
1854-5.	1 Trenched, Forked, &c.	"One seed"	4 3¾	264	63¼	696	1023	53·0	23·9	47·1
	2 Trenched, Forked, &c.	"Two seeds"	6 1¾	350	69	803	1222	54·4	20·0	52·2
	3 After Wheat	Drilled	17 1½	1006	74½	1734	2814	57·8	7·4	62·3
	Adjoining Experimental Field	Continuously unmanured ..	17 0	1007	65¾	1787	2860	59·2	6·5	60·0

more than twice as much; and, as we shall see in the next Table, in 1856, it gave once and a half as much as the continuously cropped and continuously unmanured plot.

In contrast to these very marked effects of *fallow*, it is interesting to observe, that when in 1855 this common fallow plot grew wheat *after wheat*, the produce was, within half a bushel of corn and within half a hundredweight of straw, the same as was obtained on the continuously unmanured plot of the adjoining field in that same season, which was the twelfth in succession of wheat on that plot. So perfect an illustration could hardly have been expected, of the fact of the equal *wheat-growing condition* to which these two adjoining fields were reduced by the growth of the crop; or, what is the same thing, of the absolutely equal condition for practical purposes, to which these two soils were brought, in relation to the climatic resources of growth of one and the same season.

Lastly, in regard to these effects of *fallow*, it may be noticed that in no case is the amount of produce found to be equal simply to the sum of the continuous unmanured produce of the season of the fallow and of that of the succeeding crop. That is to say, the *produce after fallow* is not simply the produce of that particular season, taken together with that of the immediately preceding season. It is the result, not only of the unexpended resource of the fallow year, and of the resources (atmospheric and terrestrial) of the actual season of growth, but there is also an effect of the season of growth (whether for increase or decrease), reacting itself upon a two years' resource; and consequently, throughout the season, upon a different stage of progress and area of food collectors of the growing plant. Or, the difference between the actual produce after fallow and the simple sum of the produce of the two years may further depend upon the more or less favourable adaptation of season as regards the *healthy development* of the crop, as distinguished from the *mere amount* of the available resources of the soil and seasons.

But with this very marked increase of crop as the result of the common fallow, how is it that the more expensive processes of trenching and forking, with the thinner seeding, &c., which on the soil at Lois Weedon yielded such excellent results, have on the Rothamsted soil been so ineffective?

Undoubtedly the too thin seeding has been one cause of this. It is also certain that the same amount of labour expended upon the Rothamsted soil as upon the Lois Weedon one, was quite inefficient to get the same amount of staple and of exposure of surface to atmospheric influences. It may be here stated, however, that the trenching at Rothamsted cost on the average about once and a half as much as is estimated by Mr. Smith. It is granted

too, that the more recent recommendation, namely, that of moulding up the growing crop in June, was only adopted in the last year of the experiment (1855), and then with little effect. But as the earlier recorded success at Lois Weedon was obtained without this—however great the improvement, as undoubtedly it is—it certainly was not an essential in the original plan.

With these unfavourable circumstances admitted then, we again ask, what is the rationale of the failure, which these circumstances have had their share in causing? Was the available mineral food for the crop deficient in this turned-up raw clay subsoil, with the good upper staple, weathered perhaps for centuries, now turned below for the descending roots to play in? Or, was it rather that the upper staple being now buried, or much intermixed with the subsoil, there was rendered available from its own, and from fresh atmospheric resources, less of the normally atmospheric food of the crop; and that the raw subsoil, but recently exposed to direct atmospheric influences, was able, so to speak, to prepare for the plant, and to accumulate for it in an available form, also less of the normally atmospheric food of plants?

On communicating our failure after four years' trial to the Rev. Mr. Smith, he suggested the probability that it was due to a want of a sufficient amount of the *mineral* constituents of the wheat-plant being rendered soluble and available; and that, in this case, the requisite supply of mineral matter should be made up by manure; believing that then, the soil having become pulverised and porous, there would be an abundant supply of *organic* substance provided by the atmosphere.

That the soil in question was not relatively deficient in soluble and available mineral food, and that, under certain circumstances, there was provided an abundant supply of organic food for a very much larger crop, was proved much more conclusively by the produce of the common fallow acre than any analysis of the soil could prove it. To test, however, in another way, what was the nature of the deficiency of the two-acre plot, trenched to a depth of 14 to 15 inches and afterwards forked, it was, after the harvest of 1855, divided into four portions, in such a manner that each of the four had an equal proportion of the trenched and forked fallow and of the stubble ground. The whole was then ploughed and prepared for sowing in the ordinary way: one portion was left unmanured, the second received mineral manure only, the third ammoniacal salts only, and the fourth both mineral constituents and ammoniacal salts. All four of the plots, together with half of the common fallow acre by their side, were then drilled with about two bushels of seed per acre in the ordinary way.

In the following table are given the results of this experiment, obtained in the season 1855-6 just passed. For the sake of comparison, there is first given, in the *upper portion* of the table, the average annual result for the four previous years, of the "*one seed*," of the "*two seed*," and of the "*drilled common fallow*" plots; and also the average for the same years, of the continuously unmanured plot in the adjoining field. And, in the *lower portion* of the table, is given the produce at the last harvest (1856), in the adjoining field (where wheat is grown year after year without or with similar manures successively), of the continuously unmanured plot, and of the plots having the same manures as those now applied to the Lois Weedon plots. The manuring of the plots was, per acre, as under:—

1. *Unmanured.*
2. *Mineral Manures only.*

   300 lbs. sulphate of potash.
   200 " " soda.
   100 " " magnesia.
   200 " calcined bone.
   150 " sulphuric acid (brown).

3. *Ammonia Salts only.*

   200 lbs. sulphate of ammonia.
   200 " muriate of ammonia.

4. *Minerals and Ammoniacal Salts.*

   300 lbs. sulphate of potash.
   200 " " soda.
   100 " " magnesia.
   200 " calcined bone.
   150 " sulphuric acid (brown).
   200 " sulphate of ammonia.
   200 " muriate of ammonia.

Looking at the *middle division* of the table, which shows the effects of manures, &c., on the trenched and forked land, and also the produce on the common fallow portion, it must be borne in mind that, in point of fact, rather more than half of the former was fallow, and less than half of it under crop, in the previous year; and that, moreover, smaller amounts of produce had been taken from this than from the common fallow portion during the four previous years. In comparing, therefore, the produce now obtained by thicker sowing, manure, &c., on this land with that on the common fallow plot, we must remember that the former was also in great part fallowed, and that the whole of it was less exhausted by previous cropping than the common fallow portion. Keeping this in mind, it is seen that the unmanured, trenched, and part-fallow portion, gave within a bushel as much corn, and actually a few pounds more straw and more total produce than the

Table II.

	Particulars of Quantity (per acre). Dressed Corn; in Bushels, Pecks, &c.	Dressed Corn; in lbs.	Offal Corn; in lbs.	Straw, Chaff, &c.; in lbs.	Total Produce (Corn and Straw); in lbs.	Particulars of Quality. Weight per Bushel; in lbs. and tenths.	Proportion of Offal Corn to Dressed as 100.	Proportion of Corn to 100 Straw.
Lois Weedon, Common Fallow, and continuously Unmanured Plots.—Average Annual Produce, 1852, 1853, 1854, and 1855.								
1. Trenched, Forked, &c. .. "One seed"	7 2¼	413	75¾	1109	1597	53·6	19·8	45·1
2. Trenched, Forked, &c. .. "Two seeds" ..	10 1¾	572	84½	1355	2012	54·4	16·4	48·9
3. Common Fallow .. Drilled	*19 3	*1110½	*88¾	*2369¾	*3569	56·2	8·0	50·6
4. Adjoining Field .. Continuously unmanured	14 1¾	833	79¾	1733	2646	55·9	14·5	50·7
Lois Weedon Plots; with Artificial Manures, and 2 bushels of Seed Drilled.—Harvest 1856.								
1. Unmanured	21 0	1251	129	2147	3527	59·6	10·3	64·3
2. Mineral Manures only	23 2	1434	100	2431	3965	61·0	7·0	63·1
3. Ammoniacal Salts only	35 1¼	2069	188¾	3842	6100	58·6	9·1	58·8
4. Minerals and Ammoniacal Salts	41 0¾	2430	133¾	4904	7468	59·1	5·5	52·3
5. Common Fallow Plot—Unmanured	21 2¾	1302	86½	2113	3501	60·0	6.6	65·7
Adjoining Experimental Field; 13th Season of Wheat year after year.—Harvest 1856.								
1. Unmanured	14 2	789	103¼	1558	2450	54·3	13·1	57·3
2. Mineral Manures only	18 3¼	1062	104¾	2012	3179	56·4	9·9	58·0
3. Ammoniacal Salts only	24 0¾	1343	162½	2818	4323	55·5	12·1	53·4
4. Minerals and Ammoniacal Salts	37 1	2159	152¼	4560	6871	58·0	7·0	50·7

* This should be the average for the four years, of what the whole acre would yield, on the supposition that only half of it was cropped each year. It is obvious, however, that as the whole acre was cropped after fallow in the first and third years, instead of half only in each of the four years, no exact comparison can be drawn. In fact, the seasons of the 2 crops after fallow were more favourable than those of the other 2 years, and hence the averages in the Table will be relatively somewhat too high for the four years of the Lois-Weedon-plan produce; though it should be remembered on the other hand, that the 4 years' produce on the Lois Weedon plan had the benefit of the previous year's fallow, and hence was the result of 5 years' resource. The following is, however, an example of the method of calculation adopted as perhaps the best under the circumstances:—

"Total Produce" of whole acre	1852	=	7,022 lbs.
" "	1854	=	7,254 "
		4)	14,276 "
			3,569 "

common fallow. It is evident, therefore, that the less produce on the trenched portion in the previous years, was in greater measure due to the thin seeding on the comparatively poor and raw turned-up subsoil, than to any relative deficiency or want of available condition of the food of the plant within the soil—*provided only* that a sufficiently healthy early development, and a sufficiently wide distribution of the underground feeders of the crop, were but obtained.

Taking the produce of this unmanured portion thus explained, as the standard by which to compare the effects of manures on land in the same condition, we find that—

"*Mineral manures only*"—gave an increase of not quite 2½ bushels of total corn, and of only 284 lbs. of straw.

"*Ammoniacal salts only*"—gave an increase of about 15 bushels of total corn, and of 1695 lbs. of straw.

"*Minerals and ammoniacal salts*"—gave an increase of rather more than 20 bushels of corn, and of 2757 lbs. of straw.

These striking results can leave no doubt that the *mineral* supplies in the soil in question were far in excess over the available and assimilable nitrogen. A comparison, too, of the middle and the lowest divisions of the Table will show that, if we take into consideration the very different condition of the land in the two cases, the effects of these manures on the Lois Weedon or trenched plots, were perfectly consistent in kind (though of course not equal in degree) with those of the same manures in the adjoining field, where they have been applied, and the crop has been grown, for many years in succession.

Hundreds of other experiments, and the whole range of recorded agricultural experience, conspire to show, that in ordinarily cropped and cultivated soils, the available mineral supplies are generally in excess relatively to the available supply of nitrogen of the soil and season, in the case of the wheat crop: in fact that, excepting in cases of very special and unusual exhaustion of the mineral or soil-proper constituents, the direct supply of them by manure for wheat does not increase the crop in any practicable and agricultural degree, unless there be a liberal provision of *available and assimilable nitrogen within the soil.* The results given above are a remarkable illustration of this. Thus, when the mineral constituents alone were added to this part fallow and only part crop-exhausted land, they gave an increase of only 438 lbs. of total produce; but when the same mineral constituents are added to the same soil with *ammoniacal salts*, the increase over and above that by ammoniacal salts alone is 1368 lbs., instead of only 438 lbs. Here, too, is a sufficient incidental proof that the minerals were added in an *available form*;—indeed, that they only required sufficient available nitrogen within the soil to yield a larger crop than

would be obtained in the average of seasons on such soil by the ordinary means of farming.

But turning now from the effect of the *mineral* constituents to that of *assimilable nitrogen* in manures, we have in these simple experiments the best answer—namely, that of direct contrary fact—to those who would endeavour to persuade the farmer, that because the soil itself contains hundreds of times more nitrogen than the largest crop of wheat, therefore the comparatively small quantity which is added in an ordinary dressing of manure can have little or no effect. We shall recur to the subject of the nitrogen in soils further on, should our allotted time permit it. In the mean time let it be prominently noted, that whilst the *minerals* alone gave a total increase of only 438 lbs., the *ammoniacal salts* alone gave 2573 lbs. of increase! And again, whilst the addition of minerals to ammonia gave an increase of 1368 lbs., the addition of ammonia salts to minerals, on the other hand, gave an increase of 3503 lbs.!

There can now be little difficulty in deciding, that it was no deficiency of available mineral food merely, which prevented the plant for itself, or the soil in the first instance for it, from acquiring a sufficiency of available and assimilable organic constituents for the growth of a very much larger crop than was in fact obtained from this expensively cultivated land. It was, on the other hand, notwithstanding the "inexhaustible" supplies of the atmosphere, and notwithstanding the enormous amount of nitrogen in the soil in some form—it was, notwithstanding these—a deficiency of *available and assimilable nitrogen within the soil*, which restricted the full action of the obviously available minerals, and which hence restricted the produce also, to an amount below the average of farming. Whilst, only make up this deficiency of available nitrogen, and the produce is increased to once and a half or twice as much.

It appears, then, that the same means which afforded the Rev. Mr. Smith his early success on the soil at Lois Weedon, were quite incompetent to yield a similar result on the soil at Rothamsted. Nay, these same means, notwithstanding that in our case they were much more costly than either Mr. Smith had found them, or than the common fallow which we tried by their side, did not even attain, for the Rothamsted soil, those mechanical conditions, without which the necessary action between soil and atmosphere could not be expected to take place. We think it indeed very doubtful whether, even if all the more recent improvements in the plan could have been fully carried out at Rothamsted, a result would have been obtained there at all equal to that at Lois Weedon. Certain it is, that soils and subsoils, which may equally be included as "*clayey*" or "*heavy*" or "*loamy*," vary almost

infinitely in degree, in physical character and texture, and in chemical qualities, under the influence of similar management and of equal climatic circumstances. We think, therefore, that considerable caution should be exercised in the application to various descriptions of land, of plans which peculiarly rely for their success on qualities of soil which are admittedly so variable in the degree of their activity.

Leaving the question of the field-experiments, let us now turn to a brief consideration of some points of great practical interest and importance, which a careful study of the relations of soil and atmosphere to produce, and of the success at Lois Weedon, cannot fail to suggest.

The main peculiarity of the Lois Weedon system of growing wheat is, that it develops to the utmost (chiefly by mechanical means), and relies exclusively upon, the resources of the soil and atmosphere, without the aid of manure: that is to say, it is sought, by the means employed, so to increase the depth of staple, and the area of distribution of the underground feeders of the crop, and so to increase the surface annually exposed to climatic influences, as to cause, not only a greater annual liberation of mineral constituents from the otherwise locked-up stores of them in the soil itself, but also a greater accumulation and elaboration, throughout its more porous and root-searching area, of the normally atmospheric food of plants, and particularly of nitrogen, in an available and assimilable form.

The principle of relying upon the stores of the soil alone, without return, for the mineral food of successive crops, is directly opposed to that laid down for the guidance of the agriculturist in the last number of this Journal by Baron Liebig. He says :—

> "Their heavy crops will perhaps not be rendered heavier by the restoration of all the mineral constituents, but they will at all events be rendered *permanent*. We shall never have a rational agriculture until, by such experiments, the law of the fertility of the soil, in reference to time, has been brought home to the minds of agriculturists."—*Journal*, p. 313.

The conclusion of the Rev. Mr. Smith, looking from the practical as well as the scientific side of the question, goes rather in a different direction. He says to his readers :—

> "The assertion is, that, on wheat land,—that is, on the great majority of clays and heavy loams,—no manure is required for wheat on this plan, since its food in abundance is there already."—*Lois Weedon Husbandry*, pp. 102-3.

And again (ibid. 103-4), referring to chemists, he says to his readers :—

"Ask them plainly, whether the soil and subsoil of clays and loams, generally though not universally, do or do not contain all that is wanted as *mineral food* for the wheat? Ask them, further, whether tillage, and pulverisation, and gradual exposure, and annual fallows, will not render soluble a sufficiency of these substances for your annual need? If they reply, 'Yes,' but demur to the plan, and add, that in time it will exhaust the capital of the land,—ask them once more, 'In how long a time?' And if they answer, 'Why, in some cases, in a thousand years or more, in others five hundred, and in some a hundred;' your rejoinder must be a smile; for you would surely feel, that even a hundred years' supply should satisfy living man."

Baron Liebig, in the article above referred to, also indignantly repudiates the notion that the cause of the efficacy of *fallow* is to be looked for in the increase of the amount of ammonia in the soil, or that any specially predominant influence was to be ascribed to the ammonia which the soil acquires in fallow. The Rev. Mr. Smith, on the other hand, speaking of the "*organic*" food—"carbonic and nitric acid and ammonia"—asks, "do not the pulverised intervals of the wheat, in the annual fallow, absorb and retain it for use?"

It is rather curious, that, with such vital inconsistencies of principle and opinion, the wheat-growing operations and success at Lois Weedon, and Mr. Smith's interpretation of them, should frequently have been brought forward in confirmation of the peculiar views of Baron Liebig. The means by which Mr. Smith obtains his large crops of *roots* also, have recently been adduced * as refutation of the views on such points emanating from Rothamsted. But the writer in question appears, as the rule, to misstate the extent and bearing of every conclusion, and even fact, which may happen to come from Rothamsted. For our own part, careful observation and inquiry on more than one visit to the spot, as well as the perusal of Mr. Smith's publications, lead us to say, that we know of no experience more calculated to confirm the opinions we have held in this Journal regarding the requirements of growth of full crops of wheat on the one hand, and of roots on the other, than that at Lois Weedon.

But to return. The question is of vital importance to practical agriculture, however little it may interest or affect the researches of "chemists and men of science,"—what is the characteristic nature of the exhaustion induced by the growth of the most important crop of the farm? And, we may add,—whether or not soils generally, or soils of any particular class, are competent, without injury, to sustain an annual extraction of mineral constituents, and to liberate, or (either by themselves or by the plants growing on them) newly to acquire from the atmos-

* Journal of Agriculture of the Highland and Agricultural Society of Scotland, July 1856.

phere, a sufficiency of nitrogen for full crops, in an available and assimilable form?

Certainly, if we were to rely upon the mean results of the 42 analyses referred to by Baron Liebig (in the last Number of this Journal) in illustration of the amount of nitrogen contained in soils, we should be led to conclude that many soils, at least, had enough of the mineral constituents of our crops for thousands of years, under the ordinary practices of *rotation*, and for hundreds of years of the growth of wheat on the Lois Weedon system. Almost all other published analyses of soils would lead to a similar conclusion; in fact, we know of scarcely any that would not. It must be freely confessed, however, that the methods by which soils have hitherto generally been analysed, have proved themselves, in their results, to be little fitted to afford the information for which the analyses were undertaken. Nevertheless, judging from the whole of the evidence of this kind at command, it may perhaps safely be concluded that, excepting the one constituent phosphoric acid, the greater proportion of soils which are termed "*heavy*," "*clayey*," or "*loamy*," do *contain*, within a workable depth, a sufficiency of mineral constituents for thousands, or hundreds, of years, as above supposed. It is, however, by no means so clear, that many of them would not fall short rather in *annual liberation in available form*, than in *actual percentage amount* of the necessary mineral constituents. Indeed, there is evidence enough in agricultural experience to show that, although the ordinary practice of rotation leaves, in most soils, a balance of *available* mineral constituents, and therefore demands a supply of nitrogen from without, yet, with this supply *alone*, the point of the requirement of more immediately available mineral constituents for full and healthy crops is in its turn frequently soon arrived at. In fact, it is the "*condition*," both as regards mineral and nitrogenous supplies, rather than the *actually existing* amount of them in the soil, that becomes defective. And in the lighter soils more especially it is, that the *condition* as regards the mineral constituents of our crops, or the *floating capital* so to speak, both bears a much larger proportion to the available stores of the soil itself, and is more dependent on restoration or supply from without.

In Mr. Smith's "*heavy land*," with its clayey subsoil intermixed, disintegrated, and well weathered (and perhaps even in his "*light* land," with its dressing of marl), it is quite clear, from the continued good results, that the annually available mineral supply, or the mineral *condition*, is not at present impaired; nor, so far as existing knowledge of such matters can be relied upon at all, need Mr. Smith be alarmed lest the dormant stores, at least of his heavy soil, should not last the century

which, he says, should satisfy living man. And it should be borne in mind, that the resources of the soil are not to be spoken of, as some are wont to do, as sufficient for—say fifty or a hundred crops, and to be cleared off to the *zero point* at pleasure, in half or double the number, accordingly as the soil is supplied with other elements of growth. Whatever the actual stores of the soil, they are only little by little available; and it is not easy to suppose that a heavy soil, yielding, under proper management, annually enough for large crops over a continuous series of years, does not contain a correspondingly enormous store in the dormant state. Whether, however, the same soil would annually yield an equal supply of available minerals if its surface were less exposed to weathering influences, and the required nitrogen for full crops were provided by manure, is quite another question.

But now let us turn, as briefly as possible, to a consideration of the nature of the evidence which analysis affords, of the amount of nitrogen contained in soils, and then, equally briefly, to a review of some of the circumstances which seem to have their share in the production of the large annual crops of wheat, without manure, at Lois Weedon.

As is well known, in 1843 Baron Liebig laid more stress than formerly on the sufficiency of the assimilable supplies of nitrogen in the atmosphere; and a few years later, after having before him the analyses of a number of soils made in his laboratory by Dr. Krocker, he superadded to the argument of the inexhaustibility of the supplies of the atmosphere, that of the large amount of nitrogen contained in soils themselves, to show that little or no effect could be attributed to the small proportion which is added in an ordinary dressing of manure; and to this he now adds, still more emphatically, in reference to fallow, that the accumulation of ammonia in the soil in one year has no influence on the crop in the succeeding year. With regard to the amount of nitrogen in the soil, we, in 1847, alluded to this point, and gave the percentage obtained by analysis of the surface-soil of the field upon which our experiments on wheat were being conducted. The necessary distinction to be drawn between the immediately available and the actually existing contents of the soil, as above referred to, was, however, too obvious to allow a moment's scepticism as to the influence of the small proportions of available nitrogen which, in our experiments, we superadded in manure. On this point, however, as it is very important to the farmer that he should be satisfied respecting it, we cannot do better than quote the replies to this argument of Baron Liebig by M. Boussingault, and by M. Kuhlmann; to the latter of whom Baron Liebig dedicates the fuller version of his paper in the

last number of this Journal, which is published as an independent work in Germany.

M. Boussingault says,—

"Latterly, M. Liebig has sought to establish that the mineral matters, the alkaline salts, are the only efficacious agents of manures, supporting this assertion by analyses which indicate in arable land, even when unmanured, a considerable proportion of ammonia; from which it has been concluded that, as the soil always contains a more than sufficient amount of nitrogenized matters, there is no necessity to supply them to it.*"

And further,—

"This alkali was determined by calcining the soil with a mixture of soda and lime. We know that, by this method, the nitrogenized substances are transformed into ammonia; but the process does not enable us to decide whether this ammonia was entirely formed in the matter examined. In fact, a soil might furnish by analysis a very large proportion of the volatile alkali, and yet we might not be justified in affirming that it contains, I will not say this alkali already formed, but even putrescible nitrogenized substances, that is to say those which are efficacious in vegetation. Thus we might extract from a soil abounding in peaty débris, from a bituminous schist, large quantities of ammonia, without, on that account, being sure of obtaining advantageous crops from such soils.

"However, it is according to the determinations of nitrogen, that M. Liebig states that a hectare of arable land, taken to a depth of 25 centimètres, contains, not the elements of ammonia, but 2000 to 10,000 kilogrammes of ammonia itself; a result presented as an objection against the necessity of the employment of nitrogenized manures. M. Kulhmann has remarked, with reason, that there is an answer to this objection in the facts themselves, and it is, that a hectare of land may contain enough of nitrogen held in stable combinations to represent as much as 10,000 kilogrammes of ammonia, and nevertheless give meagre crops, whilst, if dressed with 250 kilogrammes of ammonia in the form of manure, it will yield, after cultivation, a satisfactory produce." †

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* "Dans ces derniers temps, M. Liebig a cherché à établir que les matières minérales, les sels alcalins, sont les seuls agents efficaces des engrais, en appuyant cette assertion sur des analyses qui indiqueraient dans la terre arable, alors même qu'elle n'est pas fumée, une forte proportion d'ammoniaque; d'où l'on a conclu que le sol contenant toujours une dose plus que suffisante de matériaux azotés, il n'y a pas lieu de lui en fournir."—*Economie Rurale*, tome ii. p. 77.

† "On a dosé cet alcali en calcinant la terre avec un mélange de soude et de chaux. On sait que, par cette méthode, les substances azotées sont transformées en ammoniaque; mais le procédé ne permet pas de décider si cette ammoniaque était toute formée dans la matière examinée. En effet, une terre pourrait fournir à l'analyse une très-forte proportion d'alcali volatil, sans que pour cela on fût en droit d'affirmer qu'elle contient, je ne veux pas dire cet alcali tout constitué, mais même des substances azotées putrescibles, c'est-à-dire, efficaces dans la végétation. Ainsi, on extrairait d'un sol abondant en débris tourbeux, d'un schiste bitumineux, de fortes quantités d'ammoniaque, sans que, pour cela, on soit assuré de retirer de semblables terrains des récoltes avantageuses.

"Cependant, c'est d'après des dosages d'azote, que M. Liebig trouve qu'un hectare de terre arable, sur une profondeur de 25 centimètres, contient, non pas les élémens de l'ammoniaque, mais 2000 à 10,000 kilog. d'ammoniaque en nature, résultat présenté comme une objection contre la nécessité de l'intervention des engrais azotés. M. Kulhmann a fait remarquer, avec raison, qu'il y a à cette objection une réponse dans les faits mêmes, et c'est qu'un hectare de terre peut

M. Kuhlmann himself says,—

"Neither must the nitrogen be held in too stable combinations, as it exists in coal, the direct employment of which does not conduce to the fertilisation of the soil, but which by distillation yields a very fertilising ammoniacal liquid. Do not the same reflections apply to an objection raised against the necessity of the employment of nitrogenized manures; namely, that a hectare of land to the depth of 20 to 25 centimètres contains ammonia in quantities infinitely greater than those by means of which we seek to provide it with the elements of fertility? In my opinion, it is not sufficient that distillation should enable us to separate ammonia from the soil; it is necessary that this ammonia should be accessible to the plant without the aid of fire or of other energetic agents.

"There is moreover a reply to the objections stated above in the facts themselves; a hectare of land may contain enough of nitrogen held in stable combinations to produce 5000 or even 10,000 kilogrammes of ammonia, and yet give poor crops. If we apply to the same land 250 kilogrammes of ammonia, in the form either of ordinary manure or of pure ammoniacal salt, the fertility will be doubled.

"Agriculture is, above all, a science of facts; it is in experience that it must seek the basis of its theoretical laws." *

These, then, are the opinions of chemists as well known by their investigations in the field as by their researches in the laboratory.

Having now to record some recent determinations of nitrogen in soils made at Rothamsted, it may be well first to dwell for a moment on some of the previously published data of this kind which have been quoted by Baron Liebig. With regard to the determination of nitrogen in soils, made by Dr. Krocker in 1846, in the Giessen laboratory, it appears, by reference to the original paper (Annalen der Chemie und Pharmacie, Band 58, pp. 381-8), that he only made a single determination on each of

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contenir assez d'azote engagé dans des combinaisons stables, pour représenter jusqu'à 10,000 kilog. d'ammoniaque, et donner néanmoins des récoltes chétives, tandis que, fumé avec 250 kilog. d'ammoniaque à l'état d'engrais, il rendra, par la culture, des produits satisfaisants."—*Ibid.* p. 78.

* "Il ne faut pas non plus que l'azote soit engagé dans des combinaisons trop stables, comme cela existe pour la houille, dont l'emploi direct ne donne pas lieu à la fertilisation du sol, mais dont la distillation déplace un liquide ammoniacal très-fertilisant. Les mêmes réflexions ne s'appliquent-elles pas à une objection produite contre la nécessité de l'emploi des engrais azotés; à savoir qu'un hectare de terre à 20 ou 25 centimètres de profondeur contient des quantités d'ammoniaque infiniment supérieures à celles au moyen desquelles on cherche à lui donner des éléments de fertilité? Dans ma pensée, il ne suffit pas que la distillation permette de déplacer de l'ammoniaque de la terre, il faut que sans le secours du feu ou d'agents énergiques cette ammoniaque puisse être offerte à la plante.

"Il y a d'ailleurs à l'objection présentée ci-dessus une réponse dans les faits même. Un hectare de terre peut contenir assez d'azote engagé dans des combinaisons stables pour produire 5000 et même 10,000 kilogrammes d'ammoniaque et donner cependant des récoltes chétives. Si l'on fume cette terre avec 250 kilogrammes d'ammoniaque à l'état d'engrais ordinaire ou de sel ammoniacal pur, la fertilité sera doublée.

"L'agriculture est, avant tout, une science de faits, c'est dans l'expérience qu'elle doit chercher la base de ses lois théoriques."—*Annales de Chimie et de Physique*, vol. xx., 1847, p. 271.

the soils. We are therefore (though without calling them in question) unable to form any such judgment from the results themselves of the probable limit of error arising from manipulation and other causes, as duplicate analyses would have enabled us to do. And when it is borne in mind, that most of the published analyses show an amount of nitrogen in soils only amounting to from one-tenth to one-quarter of 1 per cent., it will easily be seen that slight errors of analysis, such as in most subjects of investigation would be quite immaterial, are here of the utmost consequence—if, at least, we should wish to discuss, by the aid of such analyses, such differences between soil and soil, or between the same soil in the conditions in which it would yield respectively a given amount of crop below a usual average, or a full one, equal to twice as much as the former. In illustration of this, we need only say that 100 lbs. of ammonia, added to an acre of soil weighing 4,000,000 lbs. (and which every intelligent farmer knows would, on most soils, increase his crop enormously), would, if well mixed with the bulk of soil, only raise its ammonia by 0·0025 *per cent.*—or 1 part in 40,000. This fact should not be lost sight of in the consideration of the figures which will shortly follow.

Next to the determinations of nitrogen in soils by Dr. Krocker, as referred to above, the most extensive series quoted by Baron Liebig is that made at the instance of the Royal College of Rural Economy in Berlin. Baron Liebig introduces these results as follows (and the italics in the second paragraph are his own):—

"The fact of the presence of this enormous amount of nitrogen in the soil has been confirmed by the researches made at the instance of the Royal College of Rural Economy in Berlin ('Annalen der Landwirthschaft,' vol. xiv., p. 2). The College of Rural Economy caused land of apparently uniform quality to be selected in fourteen different localities in Prussia for these experiments. At ten or twelve different points of each of these fields an equal quantity of earth was taken by the spade from the entire depth of the arable soil; these portions, in each case, were thoroughly mixed, and from the mass samples were taken.

"In each sample the amount of nitrogen was determined *by three different chemists separately*, and from their results have been calculated for one acre of land, to the depth of 1 foot (the specific gravity of the soil being taken at 1·5), the following quantities of nitrogen, expressed however in pounds of *ammonia* (17 lbs. of ammonia contain 14 lbs. of nitrogen)."—*Jour. Roy. Ag. Soc. Eng.*, vol. xvii., part 1, p. 285.

As these determinations are introduced to the reader by so high an authority in the matter of chemical analysis, as being made "*by three different chemists separately*," and as Baron Liebig arranges the soils in the order of their richness in nitrogen, according to the *mean* of the three experiments for each soil, it may be interesting to examine what was the sort of agreement

between the results of the three experimenters on each of the fourteen soils.* Accordingly there is given the following Table:—

In the upper portion, the percentages of nitrogen in each soil, as found by each of the three chemists, and calculated upon the soil dried at 100° C. (210° F.), are given. And—

In the lower portion of the Table, the calculated lbs. of ammonia per acre of 4,000,000 lbs.* of dry soil, according to the determinations of each separate experimenter, and also according to the mean of the three, are given. And in the last column are given, the lbs. per acre of ammonia for each soil as calculated by Baron Liebig.

So discrepant are the determinations of the three separate experimenters on the same soil in almost every case, that the results must be considered quite inapplicable as a means of arranging the soils according to their probable relative amounts of nitrogen. So great, indeed, is the discrepancy, that we find frequently once and a half or twice as much, and in several instances even ten times as much, recorded by one chemist as by another, for one and the same soil. In fact, in applying each of the separate analyses instead of the mean of the three, to estimate the amount of nitrogen or ammonia per acre, we find that one or two of the soils could be put both at the top and nearly at the bottom of Baron Liebig's list, accordingly as we select the determination of one or another of the experimenters; whilst in the same way, several others might be separated from one another by half the items in the list. It may even be a question, how far a judgment can be formed from such results, of the probable average or range of amount of nitrogen in the soils.

It is, however, only due to Professor Magnus, the able and conscientious reporter to the Royal College of Rural Economy in Berlin, of the analyses in which these nitrogen determinations are but items, to say that he called particular attention to the little agreement between the results of the different experimenters. In fact, his chief conclusion was, that as twenty-one of the best chemists in Germany, or of those working under the superintendence of the most distinguished chemists, had been selected, and as there could therefore be no want of technical knowledge devoted to the subject, it was obvious that in the existing state of science little was to be expected from the analysis of soils.

* The estimate of 4,000,000 lbs. of dry soil per acre, taken to the depth of one foot, is higher than we have been accustomed to take it; but we adopt it here, not only because it is a convenient round number, but because it obviously agrees very closely with the amount supposed by Baron Liebig, with whose estimates we are comparing our own figures. It is obvious that the cubic contents, and the weight of *available* soil on an acre, must vary extremely; so that any figure adopted in an estimate of this kind must be to a great extent arbitrary.

TABLE III.—Showing the Percentage of Nitrogen, and the supposed Ammonia per Acre calculated therefrom, in 14 Soils, each Analysed by three Chemists separately.

Nitrogen per Cent. in the Soils.

	By 1st Experimenter	By 2nd Experimenter	By 3rd Experimenter	Mean.	
1. Havixbec	0·591	0·081	0·400	0·357	
2. Burg Wegeleben	0·432	..	0·270	0·351	
3. Turgaitschen ..	0·240	0·350	0·280	0·290	
4. Wollup	0·200	0·298	0·271	0·256	
5. Beesdau	0·137	0·249	0·108	0·165	
6. Turwe	0·140	0·130	0·173	0·148	
7. Dalheim	1·609	0·150	..	0·879	
8. Laasan	0·112	0·113	0·138	0·121	
9. Eldena	{ 0·090 0·120	} 0·120	0·113	0·111	
10. Burg Bornheim	0·102	0·114	0·113	0·110	
11. Neuensund ..	0·147	0·103	0·010	0·087	
12. Frankenfelde ..	0·079	..	0·093	0·086	
13. Neuhof	0·130	0·154	0·011	0·098	
14. Cartlow	0·076	0·106	0·005	0·062	

Nitrogen calculated as lbs. of Ammonia per Acre of 4,000,000 lbs. of Dry Soil.

	By 1st Experimenter	By 2nd Experimenter	By 3rd Experimenter	Mean.	Ammonia in lbs. per Acre 1 foot deep, as given by Liebig.
1. Havixbec	28,704	3,932	19,428	17,352	18,040
2. Burg Wegeleben	20,980	..	13,112	17,048	17,200
3. Turgaitschen ..	11,660	17,000	13,600	14,084	14,350
4. Wollup	9,712	14,472	13,160	12,448	13,120
5. Beesdau	6,652	12,092	5,244	7,999	7,790
6. Turwe	6,800	6,312	8,400	7,172	7,380
7. Dalheim	78,151	7,284	..	42,716	6,970
8. Laasan	5,440	5,488	6,702	5,877	5,740
9. Eldena	{ 4,371 5,828	} 5,828	5,488	5,377	5,330
10. Burg Bornheim	4,954	5,537	5,488	5,328	5,330
11. Neuensund ..	7,140	5,002	485	4,211	4,510
12. Frankenfelde ..	3,837	..	4,517	4,120	4,100
13. Neuhof	6,312	7,480	534	4,774	4,920
14. Cartlow	3,691	5,148	243	3,026	2,870

Concurring fully with Professor Magnus on this point, and believing that little advance will be made without previous special investigation and adaptation of methods of analysis to this particular subject, it is only with the reservation which such a conviction implies, that we would now record or apply the determinations of nitrogen in soils recently made at Rothamsted

by the current methods. We may say, however, that every precaution has been taken to secure as much of accuracy as those methods are capable of. Nor are we wanting in evidence in the results themselves, that within certain limits, and for the discussion of some points of comparately broad distinction, they are sufficiently conclusive.

In the following Table (IV.) are given the results of determinations of nitrogen—in the soil and subsoil of the plot devoted at Rothamsted to the experiments on the Lois Weedon system—in the soil of the continously unmanured plot, of the continuously mineral-manured plot, of the continuously ammonia-manured plot, and of the continuously mineral and ammonia-manured plot, in the adjoining experimental wheat-field. There are also given, the determinations of nitrogen in specimens of soil and subsoil, &c., from the Rev. Mr. Smith's experimental fields at Lois Weedon. And, for the sake of comparison with the figures in Table III. last discussed, there is given in the lower portion of the Table (IV.), the amounts of *nitrogen* (in lbs.) that would be contained in 4,000,000 lbs. (= an acre about a foot deep) of the specimens analysed—both according to the individual analyses, and to the mean result for each specimen. In the last column, the mean acreage amount of nitrogen is represented in its equivalent amount of ammonia. It is obvious, however, that no actual fact is represented by thus applying the analyses of soils and subsoils indiscriminately, to a supposed equal acreage weight of soil in each case. The figures are only useful as conveying a very general comparative idea, of about how much ammonia, or its equivalent of nitrogen, would exist in a layer of one acre area, and about a foot thick, of soils or subsoils containing a given percentage amount.

It must be remarked, too, that whilst the specimens of surface-soils at Rothamsted were each taken at eight different places, and as nearly as possible to a depth of nine inches and an area of a foot square, the whole being then well mixed and re-sampled, those at Lois Weedon were each taken at one spot only; a good spit of depth being the only condition attended to. The soils at both places were collected during the present year (1856); those at Lois Weedon in August, and most of those at Rothamsted in September.

In all cases the soils were broken up and turned over and the large stones picked out; they were then further reduced and separated from smaller stones. Finally, they were rubbed to fine powder and passed through a fine sieve, in which state they were submitted to analysis. In these processes of preparation the soils were never submitted to a temperature above 60° to 70° F., and when so prepared they generally retained less, or little

TABLE IV.—Showing the amounts of Nitrogen (exclusive of Nitric Acid) in Rothamsted and Lois Weedon Soils and Subsoils.

Nitrogen per Cent. in the Soils, calculated as Dry.

		Experiment 1.	Experiment 2.	Experiment 3.	Experiment 4.	Mean.
Rothamsted	Lois-Weedon-Plot Surface Soil	0·1416	0·1418	..	..	0·1417
	Lois-Weedon-Plot Subsoil..	0·0730	0·0763	..	..	0·0746
Rothamsted Surface Soils, adjoining Experimental Field	Unmanured	0·1560	0·1450	0·1560	..	0·1523
	Mineral Manure ..	0·1430	0·1529	0·1420	..	0·1459
	Ammoniacal Salts ..	0·1530	0·1694	0·1620	0·1505	0·1587
	Minerals and Ammoniacal Salts ..	0·1520	0·1593	0·1545	0·1567	0·1556
Lois Weedon	Heavy Land Stubble	0·1640	0·1590	0·1670	0·1666	0·1641
	Heavy Land Fallow	0·2020	0·1940	0·2000	0·2090	0·2012
	Light Land Fallow	0·1630	0·1520	0·1510	0·1540	0·1550
	Heavy Land Subsoil	0·0661	0·0670	0·0667	0·0610	0·0652
	Light Land Subsoil	0·0840	0·0770	0·0760	0·0760	0·0782
	Marl Pit .. .. .. Light Land Field ..	0·0920	0·0890	..	..	0·0905
	Rye-grass Subsoil, with Liquid Manure Heavy Land Field	0·0790	0·0790	..	..	0·0790

Nitrogen per Acre about 1 foot deep—taken at 4,000,000 lbs. Dry Soil.

		Experiment 1.	Experiment 2.	Experiment 3.	Experiment 4.	Mean.	Lbs. *Ammonia* in 4,000,000 lbs. Dry Soil.
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Rothamsted	Lois-Weedon-Plot Surface Soil	5,664	5,672	..	..	5,668	6,882
	Lois-Weedon-Plot Subsoil..	2,920	3,052	..	..	2,984	3,623
Rothamsted Surface Soils, adjoining Experimental Field	Unmanured	6,240	5,800	6,240	..	6,092	7,397
	Mineral Manure ..	5,720	6,116	5,680	..	5,836	7,086
	Ammoniacal Salts ..	6,120	6,776	6,480	6,020	6,348	7,708
	Minerals and Ammoniacal Salts ..	6,080	6,372	6,180	6,268	6,224	7,557
Lois Weedon	Heavy Land Stubble	6,560	6,360	6,680	6,664	6,564	7,970
	Heavy Land Fallow	8,080	7,760	8,000	8,360	8,048	9,772
	Light Land Fallow	6,520	6,080	6,040	6,160	6,200	7,528
	Heavy Land Subsoil	2,644	2,680	2,668	2,440	2,608	3,168
	Light Land Subsoil	3,360	3,080	3,040	3,040	3,128	3,798
	Marl Pit .. .. .. Light Land Field ..	3,680	3,560	..	..	3,620	4,396
	Rye-grass Subsoil, with Liquid Manure Heavy Land Field	3,160	3,160	..	..	3,160	3,836

more, than 5 per cent. of water separable by further drying at 212°. For convenience and uniformity, the determinations in the Table are all given as calculated upon the soil so dried at 212°; though separate portions were always employed for the determination of the moisture in this way, and those of the nitrogen were always made upon the partially and only air-dried substance.

The nitrogen determinations were made by burning with soda-lime, collecting the ammonia in hydrochloric acid, and estimating as platinum salt in the usual way. It is obvious that this method does not give that portion of nitrogen which may exist as nitric acid. But from the interesting results of Professor Way, on the power of soils to absorb ammonia and nitric acid respectively, and on the general relation of these two substances in drainage-water, it may perhaps safely be concluded that, in most ordinary soils, but a very small proportion of their contents of nitrogen will be retained as nitric acid.

The two, three, or more determinations upon each soil, were in only one or two cases made by the same analyst; two persons being employed upon the series, each, as a rule, making two determinations upon the same specimen. In this way it was hoped to eliminate any prevailing tendency to high or to low results which might attach to the work of either operator. It is probable it would be the opinion of most chemists, that the discrepancies in the percentage amounts of nitrogen which the Table exhibits, are neither greater nor more numerous than were to be expected in the manipulation of the process employed, by two operators on such a series. When, however, it is remembered that, as already pointed out, the large dressing of a hundred pounds of nitrogen per acre, distributed through the soil to the depth of 1 foot, would only raise its percentage of nitrogen by 0·0025, equal $\frac{1}{40000}$th of its weight, it would at once be seen, that the separate determinations on the same soil frequently, nay, generally, differ much more from each other, than would the actual soil before and after such a potent manuring. It is clear then from this simple illustration, that such methods of estimating the nitrogen in soils are quite inapplicable to determine the difference in this respect between a soil yielding 16 bushels of wheat without manure, or twice, or twice and a half the amount, with it. That is to say, such methods are quite incompetent adequately to treat the question of the mere *temporary* "*condition*" of soils.

Exercising then all due caution, on the score both of the difficulty of fairly and uniformly sampling soils for analysis, and of that of accurately determining the nitrogen by current methods, let us see what are some of the more general indications of the

Table. For this purpose we take of course the *mean* results instead of the separate determinations; which latter, however, although disagreeing with each other sufficiently to show that the figures could not be relied upon to treat of the nice question of the effect of a single even heavy dressing of manure, have still so much of agreement, as to give some confidence at least in the *direction*, and in any marked distinctions, which the mean results would indicate as between soil and soil.

It is seen that the subsoils contain from one-half to one-third only as much nitrogen as the surface soils. From this it is obvious that an inch or two of variation in depth, in sampling a surface soil, might make a comparatively important difference in the percentage of nitrogen obtained. The effect of the admixture of more or less of subsoil, in a sample of professedly surface soil, is seen in the difference between the mean percentage in the Rothamsted soil which had been cultivated on the Lois Weedon plan, and that of a similar description in the adjoining field, which had grown wheat for several successive years, but without its subsoil being disturbed. Thus the trenched plot at Rothamsted gives a mean percentage of only 0·1417 of nitrogen, whilst the plot in the adjoining field, notwithstanding it has grown wheat for many years successively without manure, gives 0·1523 per cent.

Before proceeding to compare with one another the Rothamsted and the Lois Weedon soils, we may here, in passing, call attention to the fact that, slight as they are, and whether accidental or not, the differences which the mean results would show between the plots devoted to the continuous growth of wheat at Rothamsted, under different conditions of manuring, are really, at least in direction, such as those manuring conditions would lead us to expect. Without laying too much stress on the actual figures, it is seen, then, that whilst the continuously unmanured plot gives 0·1523 per cent. of nitrogen, that which has received for a series of years mineral manure only (which would tend to the extraction of more nitrogen from the soil than where no manure was employed) gives 0·1459 per cent., or rather less than the former. The plot which has received annually ammoniacal salts (as the results showed somewhat in excess of the available minerals), indicates 0·1587 per cent. of nitrogen; or rather more than either the continuously unmanured or the continuously mineral-manured plot. And again, quite conformably with the above, the plot which has received continuously both mineral manure and an excess of ammoniacal salts, shows a slightly lower percentage (0·1556) than where the ammoniacal salts were employed without minerals; though with this excess of ammoniacal salts, a slightly higher one than the unmanured plot.

Thus in both instances where a liberal supply of minerals has been used, the effect of which would be to use up, so to speak, more of the available nitrogen within the soil, the mean percentage of nitrogen indicated was rather lower than in the cases comparable with them on this point. It is freely granted, that some of the individual determinations are not quite consistent with the conditions here supposed; yet, with three or four experiments in each case, agreeing as most of them do pretty nearly, it is really of interest to observe, that the mean results appear to bear some relation to the known history of the plots.

Turning now to the Lois Weedon soils, it is seen that both specimens taken from the heavy-land field show a higher percentage of nitrogen than any of the Rothamsted plots, and particularly higher than the specially comparable instance at Rothamsted; namely, that where the land had been trenched and some of the subsoil intermixed with the surface soil. The Lois Weedon light land even, gives a slightly, but very slightly, higher percentage of nitrogen than the surface-soil of the continuously unmanured plot at Rothamsted. The difference, however, in favour of the Lois Weedon light land, notwithstanding it had been intermixed with subsoil and with marl, each containing only about half as much nitrogen, is more marked when it is compared with the trenched, that is, the Lois-Weedon-subsoiled plot at Rothamsted. To go to figures, we find that whilst the mean of four analyses gives for the Lois Weedon heavy-land *stubble* 0·1646 per cent. of nitrogen, the mean, also of four analyses, gives for the heavy-land *fallow* 0·2012 per cent. We cannot at all suppose that the whole of this large difference, amounting, as it would do, to from 1000 lbs. to 1500 lbs. per acre, if reckoned at 1 foot deep, is due solely to the joint influence of the exhaustion of the just removed crop in the one case, and to the accumulation by the tilled bare fallow in the other; though it is obvious, that the effect of the accumulation by fallow would not extend uniformly to the depth of 1 foot; and consequently the assumption of a gain of 1000 lbs. or 1500 lbs. of nitrogen per acre is very much higher than the figures really imply, even supposing the samples were really taken to exactly corresponding depths in the two cases. The more probable supposition is, however, that the sample taken from the stubble did in fact represent a somewhat greater depth of the staple, or more of intermixed subsoil, than that taken from the fallow interval.

Turning for a moment to the subsoils and marl, the Rothamsted unexposed subsoil indicates a rather higher percentage of nitrogen than the Lois Weedon heavy-land subsoil—the former giving 0·0746 and the latter 0·0652 per cent. It is seen, on the other hand, that the subsoil and marl of the Lois Weedon light-

land field, with which the surface-soil is intermixed, both give a higher percentage than either the Rothamsted or the Lois Weedon heavy-land subsoil—that of the light-land subsoil being 0·0782, and that of the marl 0·0905 per cent. Lastly on this point, whilst the subsoil of the Lois Weedon heavy-land unmanured wheat-plot gives 0·0652 per cent., the subsoil of the plot devoted to rye-grass, with liquid manure, in the same field, gives 0·0790 per cent.

To resume—the comparison of the percentage of nitrogen in the Lois Weedon and the Rothamsted soils submitted to Mr. Smith's methods of growing wheat, the one with so much success, and the other with such signal failure, shows that the former contain a higher percentage of nitrogen than the latter. Thus, whilst the mean percentage in the trenched plot at Rothamsted is 0·1417, that in the light land at Lois Weedon is 0·1550 per cent., and in the heavy land at Lois Weedon (taking the mean of the eight determinations on both stubble and fallow plots) is 0·1827. Independently, then, of mere physical condition of soil, of mineral richness, or of other circumstances affecting the relations of the plant to the soil, we have here an intelligible chemical difference, perfectly consistent with what all other experience regarding the requirements for the vigorous growth of the wheat-crop would lead us to anticipate.

The questions still remain, however, whether the Lois Weedon soils, in all probability, have a greater power to acquire nitrogenous plant-food from atmospheric sources, or are likely more lightly to retain, or more easily to give up to the plant in an assimilable form, their previously existing or newly-accumulated stores of nitrogen?

With a view of getting such indications on these points as limited time would permit, the following experiments were made. Rather more than one thousand grains, in a finely-powdered state, of each of the soils enumerated in the Table (V.) given below (whose nitrogen had previously been determined), were put into a water-bath for about six hours, in order to secure an equal state of dryness. Exactly one thousand grains of each were then weighed, and respectively placed in small but equal-sized basins. Each of these was then mounted upon a small porcelain pot an inch and a half in height, and so placed in a large glass basin containing water to the depth of about an inch. The large basin was then covered with another such, and the whole left for three days at a temperature of 100° or more; by which from 1½ to nearly 4 per cent. only of water was absorbed by the different soils. The water in the large basin was then replaced by pretty strong ammonia-water; and the whole, covered as before, was left for four days in a warm room, the temperature being main-

TABLE V.—Results of Experiments on the Comparative Absorptive Power, for Water and Ammonia, of different Soils.

		Water, per cent.					Nitrogen per cent. in dry Soil.				Per cent. gain of Nitrogen by absorption.	
		After 3 days in closed moist warm atmosphere.	After 4 days' Ammonia-water vapour at 70°.	Added Nov. 26.	Added Nov. 30.	Retained after 18 hours' exposure at 70°.	After absorption of Ammonia. Experiment 1.	After absorption of Ammonia. Experiment 2.	After absorption of Ammonia. Mean.	Before absorption of Ammonia. Mean.	On Dry Soil.	On previously existing Nitrogen.
Rothamsted Soil	Continuously unmanured	1·80	2·78	5·0	10·0	1·65	0·2880	0·2779	0·2829	0·1523	0·1306	85·7
Lois Weedon Soil	Heavy Land	2·53	3·35	5·0	10·0	2·48	0·3970	0·3905	0·3937	0·2012	0·1925	95·7
	Light Land	1·41	2·35			1·60	0·2547	0·2529	0·2538	0·1550	0·0988	63·7
	Heavy Land Subsoil	3·88	4·95			2·51	0·2930	0·2959	0·2944	0·0652	0·2292	351·5
	Light Land Subsoil	2·00	2·80			1·57	0·1870	0·1912	0·1891	0·0782	0·1109	141·8

tained at about 70°. Even now none of the soils had gained quite 5 per cent. of water; and as it was thought that the absorption of ammonia would be facilitated thereby, 5 per cent. was now added to each of them; and after another four days' exposure to the moist ammoniacal atmosphere, a further 10 per cent. of water was added. In four days more the little basins were removed from the ammoniacal atmosphere, and by this time the soils smelt very strongly of ammonia. In order to expel all that was not retained in a comparatively stable condition, the little basins and their contents, uncovered, were exposed for eighteen hours in the warm room at about 70°; by which, as will be seen in the Table, the amount of moisture was reduced in all cases to below 3, and in some to below 2 per cent. In this state the percentage of nitrogen was again determined in the soils by the soda-lime and platinum-salt process; and in the Table are given the results of these determinations; and by their side, the mean percentage of nitrogen in the respective soils *before* they were submitted to the ammoniacal vapours. The percentages of water in the specimens at the different stages, as above described, and the percentage *gain* of nitrogen by absorption, calculated both upon the dry soils and upon the previously existing nitrogen in them, are also given; the former to the left, and the latter to the right of the nitrogen determinations.

A glance at the Table shows that there is some general though not numerically exact connexion between the capacity of the different soils for the absorption and retention of water on the one hand, and of ammonia on the other. It is seen that the Lois Weedon heavy land and its subsoil absorbed and retained a very much larger proportion both of water and ammonia than either the Rothamsted soil, or the Lois Weedon light land, or light-land subsoil. Thus the nitrogen in the Lois Weedon heavy land, which was before the highest in the series, has been raised by the absorption experiment by 0·1925 per cent.; whilst that in the Rothamsted soil is raised by only 0·1306. The Lois Weedon light land has, however, absorbed, or at least retained, less of ammonia than the Rothamsted soil, the increased amount of nitrogen in its case being 0·0988 per cent. It is further seen that both of the Lois Weedon subsoils have absorbed more than their corresponding surface soils; the increased percentage of nitrogen by absorption of ammonia being in the heavy-land subsoil 0·2292, and in the light-land subsoil 0·1109 per cent.

It was our intention, had time permitted, to have completed other experiments of this kind for the purposes of this paper; and we may possibly yet be able before concluding to append the results of some such which are now in progress. In defect of these, however, we cannot fail to observe as a significant fact,

that the Lois Weedon heavy land, which has yielded Mr. Smith his best results, both contained more nitrogen in its original state, and absorbed and retained, under equal circumstances, both more water and more ammonia than the Rothamsted soil. The Lois Weedon light land, however, although containing slightly more nitrogen in its natural state than the soil at Rothamsted, absorbed and retained, in the experiment above described, rather less both of water and of ammonia than the Rothamsted soil. In drawing any conclusion from the results of an experiment of this kind, in regard to the probable comparative qualities of the soils in their natural state and position, we must first carefully consider what are the circumstances, in a necessarily artificial experiment, which might vitiate a strict comparison of the figures. It is to be borne in mind then, that the soils, when submitted to the absorption experiments, were in an equally finely divided state, and they would, therefore, expose nearly equal surfaces to the watery and ammoniacal vapours. The results should, therefore, show the comparative absorptive powers of equal surfaces of the respective soils. And this being so, of the three surface soils the Lois Weedon heavy land has the highest, the Rothamsted soil the next, and the Lois Weedon light land the least absorbent power in relation to a given surface exposed. But in its natural state and position the Lois Weedon light land would undoubtedly expose a much greater surface of atmospheric influences than the Rothamsted soil. Hence probably the reason that the Lois Weedon light land, though it did not absorb more ammonia in the experiment cited, yet in its natural state contained a higher percentage of nitrogen than the Rothamsted soil. Hence probably also, this Lois Weedon light land would both absorb or otherwise accumulate more nitrogen in an available form, under equal climatic circumstances, and yield it up more readily to the plant, than the soil at Rothamsted.

Since the above was in type, the additional experiments referred to have been concluded, and we give here a short statement of the results. In this second series of absorption experiments, the object was to include the surface and subsoil of the land devoted to the Lois Weedon experiments at Rothamsted; and also to submit the soils in a rather moister state to the ammoniacal vapours. 800 grains, in an equal state of dryness, of each of the soils enumerated in the Table below, had 25 septems, or about 23 per cent., of water added to them. In this state they were submitted, in the same manner as in the previous experiment, to moist ammoniacal vapours at a temperature of about 70°; though in this case for only 3 days instead of 12 as formerly. At the conclusion of the absorption period each little basin of soil was

exposed for 24 hours in the open warm room at 60° to 70°. In this condition the specimens were put into closed bottles; from each of which one portion was taken for the determination of the moisture separable at 212°, and separate portions for that of the nitrogen, the duplicate being in each case made by a second experimenter. The following are the results:—

TABLE VI.—Results of further Experiments on the comparative Absorptive Power, for Water and Ammonia, of different Soils.

Description of the Soils.		Per cent. Water retained after absorption and 24 hours' exposure at 70°.	Nitrogen per cent. in dry Soil. After absorption of Ammonia. Experiment 1.	Nitrogen per cent. in dry Soil. After absorption of Ammonia. Experiment 2.	Nitrogen per cent. in dry Soil. After absorption of Ammonia. Mean.	Nitrogen per cent. in dry Soil. Before absorption of Ammonia. Mean.	Per cent. gain of Nitrogen by absorption. On dry Soil.	Per cent. gain of Nitrogen by absorption. On previously existing Nitrogen.
Rothamsted Soils ..	Continuously unmanured	5·33	0·2498	0·2632	0·2565	0·1523	0·1042	68·4
	Lois-Weedon-Plot Surface Soil ..	5·19	0·2525	0·2462	0·2493	0·1417	0·1076	75·9
	Lois-Weedon-Plot Subsoil	5·45	0·2378	0·2239	0·2308	0·0746	0·1562	209·4
Lois Weedon Soils ..	Heavy Land Surface Soil	5·65	0·3445	0·3308	0·3376	0·2012	0·1364	67·8
	Light Land Surface Soil	4·69	0·2488	0·2425	0·2456	0·1550	0·0906	58·4

The soils being throughout this experiment in a moister state, it seems they did not become so dry by exposure in the warm room; nor were the differences in the retentive power under these circumstances so great as in the former instance. Nevertheless, conformably with the former results, the Lois Weedon heavy land retained more water than the light land, and more also than either of the Rothamsted soils. The Rothamsted subsoil, too, retains more than either of the Rothamsted surface soils, though the surface soil that had been trenched does not bear the same relation to the one which had not, in regard to retention of water, as might be expected, though we shall find it does so in regard to that of ammonia.

With regard to the absorption and retention of ammonia, the results of this second series of experiments are entirely consistent with those of the first. They may indeed be considered to be the more so, from the variation in the actual per cent. of absorption, since the circumstances of the two sets of experiments equally varied. We find, as before, that the Lois Weedon heavy land absorbed and retained more ammonia than the Rothamsted soils, and the latter more than the Lois Weedon light land. And, as was the case with the Lois Weedon soils and

their respective subsoils, the Rothamsted subsoil absorbed and retained more ammonia than its surface soil; and conformably with the greater power in this respect of the subsoil, we find the trenched land at Rothamsted absorbed and retained rather more ammonia than the one which had not had any of its subsoil intermixed with it.

In fact the results of this second series of absorption experiments confirm so entirely the bearings of the former one on all essential points, that the arguments and conclusions already recorded do not require any modification or correction from this additional evidence.

The result of the comparative examination in the laboratory of the Lois Weedon and the Rothamsted soils clearly brings out the fact, that of the former, the heavy one at least, both contained more nitrogen in some form, and had the power of absorbing more ammonia under equal circumstances, than the latter; whilst the experiments in the field have shown, that a much greater porosity, and consequently a greater amount of surface for atmospheric influences, is attained in this more highly nitrogenous, and more powerfully absorbent heavy soil at Lois Weedon, than, by an equal expenditure of mechanical means, could be attained in the one at Rothamsted. The Lois Weedon light land too, certainly contained more nitrogen than the Rothamsted soil in its natural state; and, as we have seen, would in that same state, in all probability, acquire more under equal climatic circumstances, and yield up more in a given time to the growing crop.

It would be taking a very narrow view of the case to suppose, that no other circumstances than an increased supply of nitrogen within the soil have had their share in the success of the wheat crop at Lois Weedon. There is no doubt that the methods there adopted are well fitted to develop to the highest degree the healthy distribution of both the underground and above-ground feeders of the plant. Those methods favour also the liberation, the elaboration, and the distribution throughout the root-searching area of the plant, of the mineral food of the crop, in a manner that it would be impossible to emulate in the application of direct manures. This system moreover, independently of the mere *amount* of available nitrogen provided within the soil by its means, secures also, better than any other means could do, the perfect distribution of the assimilable nitrogenous, wherever there is a liberal supply of the assimilable mineral food. It so happens too, that it is just those soils which are known to possess generally the greatest absorptive and retentive powers, that have generally also the greatest stores of most of the necessary

mineral constituents of our crops. It is not, however, all which possess these physical or chemical powers of surface, and these inherent mineral riches, that will allow, with equal ease, the exposure of an equal surface for the development and available activity of these powers and stores.

That the nitrogen shown to exist in soils by the methods of analysis which have generally been adopted, does not necessarily so exist in a form readily and within a limited period assimilable by plants, is easily demonstrable. Thus, with a view to this point, several of the soils which have been the subject of this paper were operated upon as follows. A given weight (100 grains) was put into a flask, 20 ounces of water added, and a little strong caustic potash ley. The flask was then connected by a tube with a Liebig's condenser, and heat applied so as to keep the mixture gently boiling. A series of smaller flasks, gauged and marked to hold exactly 4 ounces each, were then successively attached as receivers, until three separate fifths of the original bulk of fluid had been collected. It has been shown by Boussingault, that when very dilute solutions of ammonia or ammoniacal salt are distilled in this way, practically the whole of the ammonia will come over in the first two-fifths of the distillate. And it is obvious that boiling a soil in a fine state of division with dilute caustic potash for two or three hours, would liberate a very much larger proportion of its nitrogen in the form of ammonia than could be rendered soluble and available for plants in many years of the influence of air and moisture upon a soil in the very limited state of division in which it exists in cultivated land. Collecting, however, a distillate of three separate fifths, supersaturating each with a known quantity of a test acid, adding litmus, and then neutralising by a test alkaline solution, it was found that only a small proportion of the nitrogen existing in the soil (the quantity varying slightly with the rapidity of the distillation) was obtained in the distillates. And quite conformably with the point established by Boussingault, and confirmed in our own experiments in the case of rain-waters, the first fifth contained by far the larger proportion of the whole ammonia which came over; the third fifth, in fact, containing very little. It was, however, found, that a very much larger proportion of the total nitrogen distilled over as ammonia from the soils after they had been submitted to ammoniacal vapours as above described, than before they had been so treated.

Although, therefore, it may generally happen that a soil which contains the highest per cent. of nitrogen may have a greater aptitude, if well worked, both to acquire more and to yield up its accumulated stores, and hence, so far be more fertile, yet it is obviously quite inadmissible to suppose, that the addition of a com-

paratively small amount of nitrogen to the soil, in a form proved to be readily accessible, can be of no avail, simply because the soil itself already contains a much larger absolute amount;—though, from its distribution and state of combination, it may be but in very small proportion available within a single season. That soils are not *necessarily* more fertile because they contain a larger actual amount of nitrogen, is interestingly illustrated in the effects of burning clays. The burnt clay after some exposure, as has been shown by Professor Voelcker, contains a much less percentage of nitrogen than the unburnt. No doubt the increased supply of available mineral food, as well as the change of texture by which the roots of the plant, as well as the atmosphere, are enabled better to permeate the soil, have much to do with the result. That this is so, may indeed be judged, by a consideration of the descriptions of crop grown with most advantage after the burning process. There can be little doubt, however, that the smaller amount of combined nitrogen, newly acquired by the porous burnt soil, will be much more accessible to the plant than the larger amount locked up in the unburnt clay; and to this circumstance, in all probability, a fair share of the beneficial effects of burning should be attributed. In fact, this smaller amount of accessible nitrogen in the exposed burnt clay, has a much greater proportional effect as compared with that in the unburnt, just as the smaller amount added in manure in an available form has a striking effect in an ordinary soil, notwithstanding that the latter may contain an enormously larger amount, but in a less accessible condition.

It is further, we think, very doubtful whether ordinary *agriculturally* cultivated soils, even *contain*, in any form, so large an amount of nitrogen as the uncritical reader might be led to suppose from the statements on this point given by Baron Liebig in the last number of this Journal. The percentages given in soils by Dr. Krocker, whose figures Baron Liebig does not quote in the Paper referred to, agree very closely in range with our own experience in such matters.* Of those which he has now brought more prominently forward, and which we have quoted in full at an earlier page, the range is in some cases so high, and the discrepancies between the individual analyses of the same soil, as already shown, so great, that we are disposed to place much more confidence in the medium amounts given in that Table. Then, again, neither the Russian black earth, nor the soils of gardens or woods (the latter being the only ones given by

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* Dr. Krocker's results will be found in the Appendix to Baron Liebig's 4th English Edition of his *Chemistry in its Applications to Agriculture and Physiology*, p. 275.

Baron Liebig as analysed by himself), can be taken as parallel with ordinary farming-land, under ordinary cultivation.

With regard to any estimates that might be made from our own determinations of nitrogen in the soils at Rothamsted and Lois Weedon, of the probable acreage amount within a given depth, it may be observed, that the result obtained and published ten years ago of the amount of nitrogen in the soil of our continuously unmanured wheat plot (0·2 p. c.), was considerably higher than that now recorded in Table IV. This was to a great extent due to the fact, that the earlier sample was taken to little more than half the depth of the recent one. By reference to the analysis book we also find that, for a substance containing so small an amount of nitrogen, much too small a quantity was submitted to analysis. There is also the consideration, whether or not part of the difference is due to the reduction of the condition of the land in regard to nitrogen, by the removal of ten more unmanured wheat crops. It is clear, however, that the determination of nitrogen made upon a sample taken to only half that depth, cannot be taken in estimating the probable acreage amount to the depth of one foot. Then, again, since the analyses now recorded were made upon samples taken to the depth of only nine inches, the calculated acreage amounts one foot deep, given in the lower part of Table IV. for comparison with Baron Liebig's adopted depth of one foot, must obviously be too high. With these explanations, then, as to the degree of applicability of our figures to any estimates of acreage amounts, the results are committed to the reader, as some additional data on the many points of interest which this question of the nitrogen in soils involves.

It was our hope and intention, had our time permitted it, to have included within the limits of this paper a short review of existing knowledge, and especially of the results and tendency of the investigations of recent times, bearing upon the sources of available nitrogen to cultivated plants, both within and without the soil. It is, indeed, remarkable how many are the independent researches, from experimenters both numerous and varied in their pursuit and object, which have come in upon this field of inquiry during the last few years. It is not less remarkable, that the subject of agricultural chemistry, perhaps more than any other, has demanded and successfully incited a rigid investigation of *methods* of research; and it has, both in this country, in Germany, and in France, led to improvement, and a much greater degree of accuracy, in some of the most difficult departments of chemical analysis. Besides the establishment of methods for the determination of quantities of ammonia and nitric acid, formerly far too minute to be made the subject of successful quantitative estimation, the analysis of gases, the

peculiar influences of the sun's rays, meteorological phenomena generally, vegetable physiology in its various departments, structural and functional, not a little aided by the revelations of the microscope, are all now receiving their special study, and will find their special application in the elucidation of important agricultural questions. And, although we cannot fail to see that all will, sooner or later, conspire to give security to the next important step in these inquiries, it must be freely admitted, that as yet the difference of opinion is so great, and there really are so many points undetermined, that we may rest satisfied to delay for the present the summary we had intended to give, in the hope that, when the opportunity next occurs, we may have a less questioned advance to record.

In conclusion, the field results recorded in the foregoing pages have clearly shown that, from some cause or other, the endeavour, by given mechanical operations, to attain a deep and porous staple, with the admixture with the surface of a certain portion of the subsoil, was quite insufficient to secure in the Rothamsted soil, those conditions of texture and of other qualities incident to it, essential to the successful start, and healthy after development, especially of an early thinly-seeded wheat crop. The field experiments also afford conclusive evidence, that the defect, so far as it was chemical, was not connected with a deficiency of available mineral, relatively to available nitrogenous food. The concluding experiments showed, on the contrary, that an increased provision of nitrogen in the soil, by manure, gave a very much larger amount of increase on the now more thickly-seeded land, than an increased supply of the mineral constituents of the crop could do. That such should be the result on the land at Rothamsted, where the Lois Weedon plan had failed, was perfectly consistent with the limited degree of porosity for the exposure of surface to atmospheric influences, and for the permeation of the roots, which had been attained by the means employed. It is also perfectly consistent with those views as to the sources of the resultant effects of fallow, and as to the characteristic action of different constituents of manure on ordinarily cultivated land, upon which we have so often insisted.

The results in the laboratory again, have borne their consistent evidence on every point. Thus, bearing in mind at the same time the comparative character as to porosity of the Lois Weedon and the Rothamsted soils, it is found that, taking a given amount of each in its natural state, both of these more porous soils at Lois Weedon *contain* more nitrogen than those at Rothamsted. One of them again has, besides its greater exposed surface in the field, no doubt associated with a greater susceptibility to atmos-

pheric influences generally, a greater power of absorption for ammonia in relation to a given surface. The other of these Lois Weedon soils, although absorbing a less amount of ammonia in relation to a given weight having an equal surface exposed, undoubtedly offers, under equal circumstances in the field, a much larger amount of surface for absorption than the soils at Rothamsted. Indeed, we can have little doubt, that to the difference between the respective soils in the degree of the conjoint influences of mechanical division, and of power of absorption and liberation (in part depending on it) of a sufficiency of available nitrogen relatively to the available mineral constituents, must in great measure be attributed the difference in the results obtained at Lois Weedon and at Rothamsted.

Further, in the results which have been recorded, whether in the field or in the laboratory, we find additional confirmation of the view :—

> "That the chemical effects of *fallow*, in increasing the growth of the cereal grains, are not measurable by the amount of the additional mineral food of plants liberated thereby; these being, under ordinary cultivation, in excess of the assimilable nitrogen existing in, or condensed within, the soil in the same period of time. The amount of the latter, therefore—(*i. e.*) the *available nitrogen*—is the measure of the increased produce of grain which will be obtained."

But the system adopted by the Rev. Mr. Smith, of growing wheat year after year on alternate strips of the same land, and as a general rule without any restoration, directly or indirectly, of the mineral constituents removed in the crops, certainly does not come within the definition of "*ordinary cultivation*," as referred to in the paragraph just quoted. Whilst, therefore, a soil not only rich in the absolute amount of the mineral constituents of the crop, but one capable of sufficient mechanical division, and susceptible to the liberating action of atmospheric influences, is absolutely essential to the success of the plan, yet all experience, practical and experimental, tends to show, that a large amount of inherent mineral stores, and their easy liberation, or available form for the use of the plant, will only suffice for the production of full crops of wheat, provided there be at the same time a liberal supply of *available* nitrogen *within the soil itself.*

XXIII.—*On the Quantity of Nitric Acid and Ammonia in Rain-Water.* By J. T. WAY, 15, Welbeck Street, Cavendish Square.

IT will be in the recollection of the readers of this Journal, that, in the midsummer number for 1856, I published a paper 'On the Composition of the Waters of Land-drainage and of Rain,' in which I gave analyses of the rain-water of each month in the year 1855, collected at Rothamsted, and kindly supplied to me for the purpose by Mr. Lawes.

In order to save the necessity of reference, I will very briefly state the results of that examination. It should be premised that, up to the time from which the investigation in question dates, the methods in existence for the determination of the very minute quantities of nitric acid and ammonia present in rain-water were of so faulty and incomplete a character, that no reliance could be, or by competent judges was, placed in the few isolated results which had been published on this head; and opinions on the amount of influence which the nitrogenous elements of rain-water might exercise on vegetation, were loose and speculative in the extreme. By the aid of entirely new and highly refined methods of analysis, I was enabled to ascertain with certainty what quantity of nitric acid and ammonia was brought down to the soil by the rain-water of each month in the year 1855. It was found generally:—

1. That the total quantity of nitrogen brought down in the form of rain was much smaller than had been previously supposed, and that it was altogether insufficient to account for the amount of produce obtained naturally in uncultivated and unmanured soils.

2. That of the nitrogen so brought down by rain, very much the larger proportion existed in the state of ammonia.

3. That, as a rule, both the ammonia and nitric acid falling in rain in any one month were in direct proportion to the quantity of such rain, modified only to a certain extent by the number of occasions on which rain had fallen.

4. That nitric acid was found in the rain of each month of the year, and consequently, if it be the result of electrical action, such action must be continuously in exercise and not confined to special seasons.

Such were the general conclusions which seemed justified by the analysis of the rain-water of different months in the year 1855. It seemed desirable that this investigation should be extended over a second year, and accordingly, by the help of Mr. Lawes, who has a second time placed samples at my disposal,

I am in the position to publish analyses of the waters of each month of the present year (1856), together with those of a few selected samples of the rain of thunderstorms, &c., which seemed likely to throw light upon the formation of these compounds in the air.

The following Table shows the quantity of nitric acid and ammonia per gallon of rain-water during each month of the year 1856, and, for the sake of comparison, the figures before published for the year 1855 are given in another column.

TABLE I.—Nitric Acid and Ammonia in Rain-Water.
(Grains in the Imperial Gallon).

	Ammonia.		Nitric Acid.	
	1855.	1856.	1855.	1856.
January	0·092	0·079	0·017	0·025
February ..	0·104	0·136	0·042	0·018
March	0·086	0·093	0·021	0·035
April	0·123	0·146	0·035	0·018
May	0·080	0·127	0·035	0·028
June	0·135	0·113	0·080	0·047
July	0·061	0·085	0·017	0·035
August	0·080	0·070	0·060	0·035
September ..	0·095	0·121	0·021	0·035
October	0·061	0·060	0·036	9·032
November ..	0·054	0·080	0·018	0·043
December ..	0·067	0·080	0·017	0·040

The differences in the quantities of ammonia and nitric acid of the two years are only such as would be anticipated from the circumstances of the case, whilst the general resemblance of the figures is a sufficient proof of their correctness. But little information, however, is to be obtained from these results, except in connection with the quantity of rain falling. The following Table exhibits the rainfall per acre, with the quantity of nitric acid and ammonia contained in it. The fourth column shows the quantity of nitrogen in both these compounds.

The reader who will take the trouble to compare this Table with the corresponding one for 1855 in the last number of the Journal, will find that, although there are some differences in the two, the present figures substantially bear out my previous results. The total amount of nitrogen present in both its compounds is somewhat greater in the rain-water of the year 1856 than in that of last year, but not to such an extent as in any way to modify the practical conclusions to which we were led when detailing the former experiments. It would be a waste of time therefore to go over these arguments again. It is quite obvious that the nitrogen of *rain* is not adequate to account for the in-

fluence of the atmosphere as a source of nitrogenous manure to the soil and plants.

TABLE II.—Nitric Acid and Ammonia in Rain-Water per acre, 1856.

	Gallons of Rain.	Nitric Acid in Grains.	Ammonia in Grains.	Total Nitrogen in Grains.
January	62,952	1561	5005	4526
February	30,586	544	4175	3579
March	22,722	806	2108	1945
April	59,083	1063	8614	7369
May	106,474	3024	18313	15863
June	43,253	2046	4870	4540
July	33,561	1191	2869	2670
August	59,859	2125	4214	4021
September	49,477	1756	5972	5373
October	65,033	2075	3921	3767
November	32,181	1371	2591	2489
December	50,870	2035	4070	3352
Total in lbs. the whole year	.. ..	2·80	9·53	8·31

In addition to the samples for each month of the year, Mr. Lawes has kindly supplied me with a few specimens, which might be supposed to give interesting results—they are as follows:—

June 20.—Heavy thunder-rain after about a week of showery and apparently thundery weather, but without actual sound of thunder. This was the largest fall in any day of the year (0·9676 of an inch). It contained—

Nitric acid .. .. 0·035 grains per gallon.
Ammonia .. .. 0·091 „

This is if anything rather below the average quantity of both substances in the rain of the year.

August 9, A.M.—Thunder-rain after very hot dry weather for 8 or 9 days (0·1782 of an inch in the day)—

Nitric acid .. .. 0·089 grains per gallon.

The quantity of water at my disposal did not allow in this case and others that follow of an estimation of ammonia.

August 9, P.M.—Thunder-rain, moderate fall—

Nitric acid .. .. 0·0355

August 11.—Heavy thunder, small fall of rain (0·0710 of an inch)—

Nitric acid .. .. 0·1243

These last examples well illustrate the fact that the percentage of nitric acid is in inverse relation to the fall of rain: when the latter is large, we have a small proportion per gallon of nitric acid; on the other hand, when the rain is small, we find a higher *relative*, though not a larger *actual*, quantity of nitric acid.

The nitric acid of the thunder-rain is certainly very high, but, as will be seen shortly, it is not very much greater than the water of mist and fog, and we are hardly justified in considering these results as corroborating the theoretical explanation of the production of nitric acid by electrical action.

September 2.—Thunder-rain—

Nitric acid .. .. 0·035

October 22.—Frost, mist, fog, &c.—

Nitric acid .. .. 0·071

October 27.—Fog, mist, &c.—

Nitric acid .. .. 0·071

October 28.—Fog and mist—

Nitric acid .. .. 0·089

October 30.—Fog, mist, and little rain—

Nitric acid .. .. 0·088

November 27.—Snow which fell on the 26th, melted, and collected with rain on the 27th, large total fall—

Nitric acid .. .. 0·053
Ammonia .. .. 0·654

The quantity of ammonia in snow is here seen to be comparatively very large, a circumstance which has been repeatedly observed, and which was confirmed by the late experiments of M. Boussingault.

December 5, A.M.—Snow which fell on the 2nd and 3rd, melted, collected with rain on the 5th, moderate fall—

Nitric acid .. .. 0·0461

December 5, P.M.—Little rain, very misty all day—

Nitric acid .. .. 0·053

It appears to me that all that we can legitimately conclude from these results is, that neither in the case of nitric acid nor ammonia is the quantity present in the air sensibly increased by such influences as electricity, heat, &c.; for so far as the water of rain is concerned these compounds of nitrogen are evidently inversely proportionate to the quantity of water falling. In the cases of thunder-rain, the fall being slight, we have a large proportion of nitric acid, although even then not much greater than is found in the water of fogs and mists where the influence of heat or electricity is not supposed. Where, however, a fair quantity of rain falls accompanied with thunder, we find only the average proportion of nitric acid. The refreshing influence on vegetation of a thunder-shower is due to the much-needed water *as* water, and not to its being a vehicle of nitrogenous manure.

MISCELLANEOUS COMMUNICATIONS AND NOTICES.

VII.—*Cultivation and Tenure of Land in Scotland and the Channel Islands.* Communicated by CHARLES BOWYER ADDERLEY, M.P., Hams Hall, Coleshill.

Extract of a Letter.

October 20, 1856.

I HAVE, within the last few weeks, visited Scotland and the Channel Islands, and I cannot say how much I have been struck by the contrasts which those extremes of the United Kingdom exhibit in their rural economy. I had heard much of the progress which the system of giving leases and letting farms by tender had made of late years in Scotland, but I had no idea of the extent to which it has been already carried. I believe it is now as rare to find a farm unleased in Scotland as to find one leased in England. The usual term is either 19 or 21 years, and the farmer no more considers that he has a claim to renewal at the end of it than he has to the fee-simple of the land. He makes his calculations entirely on the basis of keeping the farm so long, and no longer; if he looks to getting a renewal, it must be by paying at least as high a rent as can be got in the market, for he knows that tenders will be advertised for, and, *cæteris paribus*, the highest taken. The sums invested by farmers in permanent improvements on certain, though limited tenures, guaranteed by lease, are almost incredible. A very intelligent Tweedside farmer told me that a neighbour of his, a tenant of Sir Thomas Brisbane's, had invested 40,000*l.* (including stock) on a farm of 1000 acres, for which he paid 2*l.* 2*s.* an acre. This is probably an extreme case, but 20*l.* an acre is by no means uncommon. Yet all agree that no business has paid better than farming for the last ten years. Under the new system rents have risen enormously, in many cases 50 per cent., and it is satisfactory to find that the labourers have shared in the general prosperity, wages having risen from 10*s.* or 11*s.* to 14*s.* or 15*s.* in the agricultural districts. One farmer told me he gave in harvest 18*s.* and food. It is strange that in Scotland, where so much of feudal sentiment has lingered so long, and indeed still lingers, this purely commercial system of land-letting should have established itself, while in England it is hardly known. The cause, I think, lies not in any deliberate change of opinion or feeling, but in the necessities of the Scotch landlords, who have been driven to turn their property to the most profitable account,

without reference to any other consideration. In England, on the other hand, the landlords have acted under the influence partly of personal sympathies and attachments, and still more of a desire to keep up their political power, and they can, generally speaking, afford to make pecuniary considerations subordinate to such motives.

Well, in Jersey and Guernsey you see the precise converse of what I have been describing. Instead of large farms, scientific agriculture, and a shifting tenantry of educated gentlemen-farmers, with large capital and commercial ideas, you have farms averaging 10 acres (each farm generally a separate estate), primitive though careful cultivation, families living upon and farming the same land for hundreds of years, and apparently much in the same way and with the same tools as hundreds of years ago. Each of these little estates or farms is divided from its neighbour by an immense hedgerow, so that the country from a height looks like a continuous wood. The farmhouses are substantial stone buildings, as good externally as ordinary farmhouses in Warwickshire, but the people live, I was told, more hardly and poorly than English labourers, very rarely eating meat, and scarcely taking as much rest as is sufficient to preserve health, such is their covetous industry. The amount of produce that they get out of the land is marvellous, the average rent of it being quite 4*l.* an acre. It is curious to see how each of the two systems I have been describing, opposed as they are to each other, results in immense produce, far greater than what may be called the intermediate system, which prevails in England, does. I suppose, the largest amount of all is produced in the Channel Islands, but then they have great advantages in their soil and climate (which, I think, are on the whole more favourable to vegetation than any other that I have seen), in the abundance, close at hand, of seaweed manure, in (what may be called) an artificial market afforded by 4000 or 5000 resident strangers, and in the remarkably industrious, laborious, and acquisitive character of the Norman race which inhabits them — a character which appears to compensate by the possession of those qualities for the want of Anglo-Saxon intelligence and enterprise. At any rate, the rural economy of Guernsey and Jersey is not transplantable; it may subsist and prosper indefinitely in these days where it has been handed down, but no one would think of creating it where it did not exist; whereas the Scotch system, with all its drawbacks (and in a moral and social point of view they are many), is conceived in the very spirit of the age, and will, I have no doubt, eventually prevail throughout the whole of this kingdom.

VIII.—*Prevention of Injury from the Turnip Fly.* By T. L. Thurlow.

Sir,—Finding that the statements from different agricultural districts report much loss to the swede crop from "the fly," I am induced to communicate a plan which has this season been accidentally tried here, and, as far as I can judge, found to answer, in the hope that at all events it may attract the notice of practical farmers, and induce them to consider the subject.

In the beginning of July last I told my father's bailiff to drill a 9-acre field with swedes, and left home the day after; on my return, on asking him about the field, he stated that the field was drilled, but that, not having swede seed enough, and thinking it very late for swedes, he had drilled half swedes and half turnips, viz. 1½ lb. of each to the acre.

On walking over the field some little time after, I found a fair crop of swedes, but hardly a single turnip (there are not twelve in the field). It appears that the fly took the whole of the turnips, but left the swedes. The impression on my mind was that the turnip-seed was bad, but on testing it by growing some in pots it was found to be good.

About two weeks previously to the time when the 9-acre field was drilled, 2 acres of ground at a little distance from it were drilled with swedes from the same batch; they were drilled in with 2 cwt. of superphosphate and 15 bushels of wood-ashes to the acre, the field having been previously manured with 17 loads of fatting dung to the acre. These swedes came up and grew away well, but the fly took the whole.

During the turnip season of 1855 the fly was very troublesome (they had about half destroyed a field of turnips), when, thinking it was necessary "to do something," I set out 3 equal plots in the field, and having had a little hand dusting machine made to take 2 drills at a time, while the dew was on the ground, had No. 1 plot dusted with soot; No. 2 with soot and lime in equal quantities; No. 3 with lime. The total quantity in each case used for dusting was about 3½ bushels per acre.

The result of this experiment was that the fly left No. 1 plot undamaged, but injured No. 2, and comparatively speaking still further injured No. 3—saving only about one-half of the plant then left.

Baynard's Park, Guildford,
November, 1856.

IX.—*On certain Obstructions which form in Draining-Tiles.* By M. Hervé Mangon.* Translated from an article in the French Scientific Review, the 'Cosmos.' By J. Evelyn Denison, M.P.

In certain soils the water from drains forms, more or less quickly, a deposit of solid matters which create an obstruction in tiles, prevent all flow, and render the work done useless. This is the most serious mischief which can happen to works of drainage; and unless it can be prevented, it is vain to attempt the improvement of lands liable to be so affected, by draining. The obstructions formed in tiles by the chemical deposit of substances held in solution in the drainage-water are of two different natures. One is formed principally of carbonate of lime; the other contains a large proportion of oxide of iron, and exhibits an ochreous colouring, which has acquired for it the name of the ferruginous deposit.

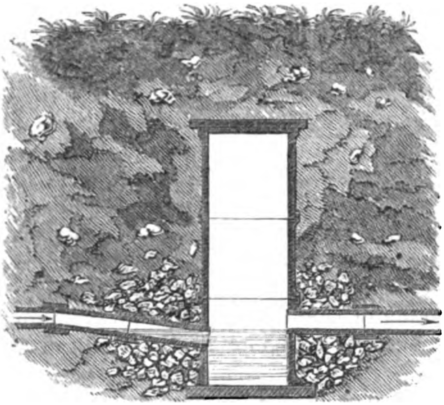
I will now explain the results of my investigations into these two classes of obstructions, and the simple means by which I am enabled to prevent their formation in draining-tiles.

Calcareous Obstructions.—Spring waters in calcareous soils contain sometimes a sufficient proportion of carbonate of lime to form incrustations; that is, they will deposit by exposure to air a greater or less proportion of calcareous salts. The same phenomenon occurs in draining-tiles; the bore rapidly diminishes, soon it becomes insufficient to allow a passage for the water which should flow through them, and the fruits of a great outlay are entirely lost. Waters charged with carbonate of lime hold it in solution by means of the carbonic acid gas which they contain. They remain limpid as long as the gas does not disengage itself. The calcareous deposit is only formed when the quantity of carbonic acid is no longer proportioned to the calcareous salt which the water contains. The formation of calcareous substances in drains may therefore be obviated by preventing the disengagement of the carbonic acid in the water which runs in the drains. This is easily done by cutting off all communication between the drains and the external air. The small quantity of atmospheric air in the subterraneous conduits soon imbibes carbonic acid in proportion to the volume of gas dissolved in the water. This has then no longer a tendency to disengage itself. The water charged with the calcareous matter preserves its limpidity, and the flow may continue without interruption. Nothing is more easy than to realise this in practice. It is only necessary to place an air-trap (un regard pneumatique)

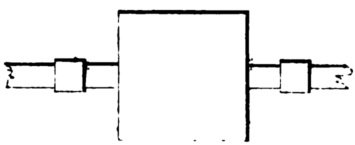
* M. Mangon's paper was read at the Institut Impérial de France, Académie des Sciences, and received with approbation, at the sitting of August 25, 1856.

a few yards above the outfall, and, if it can be conveniently done, at the points of junction of the main drains. These air-traps are constructed like ordinary traps, with two or three large tiles placed vertically on a flat stone, or upon a large flat tile, and covered in the same manner; a little bit of solid work in brick or masonry is placed at the base of these traps. The tiles which discharge into them, in greater or less number, are solidly fixed, and sometimes built in for a short distance to avoid all danger of displacement. But contrary to the plan pursued with the ordinary trap, the *conducting* tile, to which an increased fall is given for a short distance, is placed at a *slightly lower level* than the *discharging* tile; by this device the drain-tiles are cut off from all communication with the outward air, and the desired condition is obtained.

Air-trap.



Cutting.



Plan.

Ferruginous Obstructions.—The obstructions of this nature are formed by abundant deposits of a muddy or gelatinous consistency. Their tint varies from deep red to faded ochreous yellow. When the deposits are formed in calm water you see pellicules of varied hues appear on the surface, which the smallest agitation precipitates to the bottom. These deposits rapidly choke tiles of any dimensions, and completely stop the flow of the water. The waters in which these deposits are formed are those especially which spring from lands rich in oxide or in sulphate of iron, from bogs, from peaty grounds, and from lands exposed to infiltrations from woods placed on a higher level. The products designated by the names crenic and apocrenic acids play an important part in the production of these deposits. The study of them in a purely chemical point of view merits attention, and I propose to undertake an examination of them as soon as a favourable opportunity permits me to collect a mass of materials sufficient for the inquiry. For the present, in a practical point of view, the following facts will suffice:—The composition of

these deposits is necessarily very variable. It depends doubtless on the nature of the soil traversed by the waters which produce it. On the other hand, the deposits are almost always mechanically compounded with indeterminate, but often considerable, proportions of clay, of fine sand, and of vegetable detritus.

To give an idea of the differences of composition which exist between one sample and another, the three following analyses are supplied:—

	1.	2.	3.
Sand, iron, and clay insoluble in hydrochloric acid	17·00	29·75	76·75
Alumina	3·67	3·75	5·75
Oxide of iron	37·67	49·70	4·75
Carbonate of lime	6·33	8·48	3·66
Carbonate of magnesia	..	3·24	1·14
Water in combination, substances not proportioned, and combustible organic matter, azote not included	34·67	3·07	7·55
Azote	0·66	2·01	0·40
	100·00	100·00	100·00

Sample No. 1 was collected in the environs of Cassel; it was only dried in the air. The other two, before analysis, were dried at a temperature of about 80°. Sample 2 was collected in the environs of Arras, and sample 3 comes from Henonville (Oise). I boiled 100 portions of these samples with potass.

	Sample 2.	Sample 3.
Silica	7·63	5·35
Alumina	traces	2·15
	7·63	7·50

An analogous deposit, collected at Drayton Manor, and analysed by Mr. Phillips of London, furnished—

Silica and alumina, with traces of lime ..	49·20
Peroxide of iron	27·80
Organic matter	23·00
	100·00

It would be difficult, as I said at the beginning, to deduce very useful conclusions from these figures without more detailed research. It is not the same with regard to the following facts, of which the practical interest will easily be appreciated. When you collect a recent deposit, and some of the water from which it is formed, by passing the whole through a filter you will obtain a liquid perfectly pure. This liquid, enclosed in bottles, entirely filled, and well corked, or placed in an atmosphere quite deprived of oxygen, preserves its transparency indefinitely. Exposed to the action of oxygen, or of atmospheric air, it becomes

turbid in a few moments, and begins to deposit the ochreous matter which forms the basis of the obstructions of which we are treating. The deposit collected in the drains, or in the ditches into which they discharge themselves, may be easily freed from the liquid by washings with pure water. By exposure to air the tint becomes more red. When after some hours it appears no longer to vary in colour, the deposit is placed in a bottle filled with water and well corked: the red tint will be seen to become by degrees dark brown or almost black. After some weeks, if the produce is filtered, a pure liquid is again obtained, but which rapidly becomes turbid by exposure to air, and allows the ochreous deposit, of which I have spoken, to form. At the same time the deposit left behind in the filter resumes the red tint which it presented at the moment it was enclosed in the bottle. The same series of observations may be repeated several times by the same sample. The product in question presents then this double character: it becomes insoluble by its oxydation, and it is able, when left to itself, to reduce itself, so as to become partly soluble. If you place three or four cubic centimètres of the ochreous precipitate, recently collected, and saturated with the water from out of which it was formed, in a prover filled with oxygen, secured over a bowl of mercury, the absorption of gas is at first very rapid, then it slackens by degrees, and at last ceases altogether. During the first eight days of one of my experiments 14 cubic centimètres of gas were absorbed, while on the thirteen following days 5 cubic centimètres only disappeared. The mass was then completely of a red tint, and, put through a filter, gave a clear liquid, and did not contain in solution any product worthy of remark. The liquid which impregnates the new precipitates contains variable proportions of substances precipitable by the action of air. We have obtained up to 0·80 per litre, although the action of the oxygen had already precipitated a part of it. Commonly from 0·25 to 0·50 per litre will be found, which is sufficient, on account of the lightness of the product and its gelatinous consistency, quickly to produce an obstruction in tiles. From these facts it results—

1. That the waters which produce the ferruginous obstructions in tiles preserve their limpidity, and do not form any deposit, when they are placed beyond the reach of the oxygen of the air.

2. That a deposit recently formed can exert upon itself a reducing action which makes it in a great degree return to a soluble state.

From these two facts it is easy to conclude that air-traps resembling those described in speaking of calcareous deposits, will equally prevent the formation of ochreous deposits in drain-tiles. In the second case the trap, instead of preventing the dis-

persal of the carbonic acid, as in the first case, will prevent the entrance of the oxygen of the air. If a little of the gas reaches the tiles during great droughts, or with the water of the first rains, some deposits, it is true, may accidentally be formed, but they will re-act upon themselves after having absorbed the oxygen contained in the air of the tiles, they will speedily return to a soluble state, and they will be easily carried along by the movement of the water in the drains during the rainy season.

It is superfluous to add that drains formed in land subject to produce these ferruginous obstructions ought to be executed with more than ordinary care. The refilling of the trenches ought above all things to be attended to. The most argillaceous parts of the soil should be chosen to place over the tiles; these should be chopped fine and carefully rammed in the most perfect manner. The composition which forms the basis of these ferruginous incrustations in drain-tiles is found in great quantities in soils circumstanced as above described. It is equally found, but in smaller proportions, in many other soils. It probably plays an important part in the phenomena of vegetation. It is not impossible, indeed, that it is in this particular state of combination that iron introduces itself into the tissue of plants. It is very probable that ammonia may be formed during the oxydation of this substance, as it is formed when iron rusts in the damp air. The experiments which I have in hand may, I hope, place beyond doubt this reaction so interesting for agriculture.

The chemists who have spoken of the ferruginous obstructions of drains, supposed with reason that these deposits were due to the oxydation of the salts of the protoxide of iron. It was generally thought, however, that they were formed by the precipitation of a certain quantity of the carbonate of the protoxide of iron, produced in the bosom of the earth by the action of the organic materials on the peroxide of iron, and held in solution in the water by an excess of carbonic acid. The solubility of the carbonate of the peroxide of iron is *insufficient* to explain the abundance of some of these deposits. No one, moreover, had demonstrated positively the absorption of the oxygen, and no one had observed the spontaneous reduction of the deposit, which completely insures the success of the air-traps of which I have now pointed out the use to prevent the ochreous obstructions in drain-tiles.

HERVÉ MANGON.

The draining operations in which I have been engaged have been chiefly confined to clay soils, and I have no experience of the difficulties caused either by the calcareous or the ferruginous

deposit. I have, however, seen the mischievous effects of the latter in boggy grounds drained by the Duke of Portland. The drains were constantly choked by the deposit, called by the workmen the red ochre. I have inquired of Mr. Tebbett, the head-drainer of the Duke of Portland, whether he has found any remedy for this evil—an evil of a serious magnitude, occurring as it does in drains of from 8 to 12 feet deep, the reopening of which from the surface causes a very heavy expense. Mr. Tebbett says, in answer, that the only remedy with which he is acquainted is to flush the drains with fresh water, by applying it from a shaft built at the head of the drains. He finds this ochreous deposit occurs generally in drains made in boggy land, upon sand-rock, and not far from running water. When first made these drains require flushing every five or six weeks; after a time the deposit becomes less, and a larger period may be allowed between the times of flushing. If an air-trap would correct the evil, it could in most cases be easily made, and would be a valuable improvement.

J. Evelyn Denison.

END OF VOL. XVII.

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Royal Agricultural Society of England.

1856—1857.

MEMORANDA.

ADDRESS OF LETTERS.—The Society's office being situated in the new postal district designated by the letter W, members in their correspondence with the Secretary, are requested to subjoin that letter to the usual address.

GENERAL MEETING in London, on Friday, May 22, 1857, at Twelve o'clock.

COUNTRY MEETING at Salisbury, in the week commencing July 20, 1857.

GENERAL MEETING in London, in December, 1857.

MONTHLY COUNCIL (for transaction of business), at 12 o'clock on the first Wednesday in every month, excepting January, September, and October: open only to Members of Council and Governors of the Society.

WEEKLY COUNCIL (for practical communications), at 12 o'clock on all Wednesdays in February, March, April, May, June, and July, excepting the first Wednesday in each of those months, and during adjournment: open to all Members of the Society, who are particularly invited by the Council to avail themselves of this privilege.

ADJOURNMENTS.—The Council adjourn over Easter week, and occasionally over Passion and Whitsun weeks; from the first Wednesday in August to that in November; and from the first Wednesday in December to the first Wednesday in February.

GUANO analysed for Members at a reduced rate by Professor WAY, at 15, Welbeck Street, Cavendish Square, London.—(Statement of Members' Privileges of Chemical Analysis given in Journal, vol. XVII., Appendix, pp. xiii, xlvi, and may be obtained separately on application to the Secretary.)

DISEASES of Cattle, Sheep, and Pigs.—Members have the privilege of applying to the Veterinary Committee of the Society; and of sending animals to the Royal Veterinary College, on the same terms as if they were subscribers to the College.—(Statement of Members' Veterinary Privileges given in Journal, vol. XI., Appendix, pp. viii, ix; vol. XII., Appendix, p. iv; vol. XIII., Appendix, p. xxxiv; vol. XIV., Appendix, p. v; and may be had separately on application to the Secretary.)

LOCAL CHEQUES: requested not to be forwarded for payment in London; but London Cheques, or Post-office Orders (payable to "James Hudson"), to be sent in lieu of them. Members may conveniently transmit their Subscriptions to the Society, by requesting their Country Bankers to pay (through their London Agents) the amount at the Society's Office (No. 12, Hanover Square, London), between the hours of ten and four, when official receipts, signed by the Secretary, will be given for such payments.

NEW MEMBERS.—1. *Nomination:* Every candidate for admission into the Society must be proposed by a Member; the proposer to specify in writing the name, rank, usual place of residence, and post-town, of the candidate, either at a Council, or by letter to the Secretary. Every such proposal will be read at the Council at which such proposal is made; or, in the case of the Candidate being proposed by a letter to the Secretary, at the first meeting of the Council next after such letter shall have been received.—2. *Election:* At the next Monthly Meeting of the Council the election will take place, when the decision of the Council will be taken by a show of hands; the majority of the Members present to elect or reject. The Secretary will inform Members of their election by a letter, in such form as the Council may from time to time direct.—Candidates residing out of the United Kingdom can only be elected as Life-Governors or Life-Members of the Society, and are in each case required to make in one payment on election a composition in lieu of annual subscriptions.

*** Members may obtain on application to the Secretary copies of an Abstract of the Charter and Bye-Laws, of a Statement of the General Objects, &c., of the Society, and of other printed papers connected with special departments of the Society's business.

Royal Agricultural Society of England.

GENERAL MEETING,

12, Hanover Square, Saturday, Dec. 13, 1856.

REPORT OF THE COUNCIL.

The Society consists at the present time of—

85 Life Governors,
137 Annual Governors,
862 Life Members,
3,917 Annual Members, and
19 Honorary Members,

making a total of 5,020 Members, or an increase of 41 names on the list of the Society since the last Half-yearly Meeting.

The Council have elected the Earl of Powis and Mr. Edward Pope to supply the vacancies respectively occasioned in the Council by the transfer of Mr. Evelyn Denison, M.P., to the class of Trustees, and the lamented decease of Mr. Hampden Turner.

The Funded Capital of the Society stands at the same amount as reported at the last General Meeting, namely, at 9,264*l.* 8*s.* 11*d.* in the New Three per Cent. Consolidated Stock.

The following Prize-Schedule for the Essays and Reports of next year, to be sent to the Secretary by the 1st of March, and to be subject to the usual conditions of competition, has been adopted:—

1. The results of microscopic observation applied to the vegetable physiology of agriculture	£50
2. The best mode of levelling ridge and furrow pasture land after drainage	20
3. The permanent amelioration of soils by admixture with others	20
4. Destruction of vermin infesting the homestead and stackyard	10
5. The comparative advantages of entering upon farms in spring and autumn, together with instructions to the young farmer on his entry at either season	20

6. The results of drilling wheat or barley at different distances with the same quantities of seed; and also with varied quantities of seed per acre £10
7. On the early or late sowing of root crops 10
8. On the comparative advantages of sowing beans in spring and autumn 10
9. Any other agricultural subject 10

Professor Way, the Consulting Chemist to the Society, has delivered to the Members a second time his lecture on the chemical composition of the waters of land-drainage, for the purpose of detailing the further progress of his researches on that subject; and the Council have adopted a new scale of charges to be made to those Members of the Society who may avail themselves of their privilege of consulting him, or obtaining from his laboratory chemical analyses, at reduced rates. Professor Simonds, the Veterinary Inspector of the Society, has delivered the concluding portion of his lecture on destructive parasites attacking the internal organs of the body in the case of different domesticated animals.

The Country Meeting at Chelmsford has proved eminently successful in carrying out the objects of the Society, although the expenses incurred have entailed a heavy charge on its general funds. The interest attached to the exhibition of live stock, on that occasion, was increased by the great number of horses shown for the Local Committee's Special Prizes, and the select Specimens of Foreign Stock sent over to the meeting at great expense by the French Government, as a token of friendly regard towards the Society and its national objects. The implements gave evidence of distinct improvement in their simplicity and efficiency; and the trials in the field, as well as the public working of machinery in the show-yard, were witnessed with deep interest by a numerous concourse of spectators. The reaping-machines and steam-cultivators were reserved for subsequent trial; and the Council have voted to Mr. Fisher Hobbs their best acknowledgments of the kind manner in which he offered his land for the purposes of that trial, which took place in August last; for the liberality with which he placed men and horses at the disposal of the Stewards and Judges for working the machinery;

and for the facilities he so readily afforded in rendering the trial satisfactory to all parties. The Judges have made a special report to the Council on the trials made by them of the steam-tillage apparatus respectively exhibited by Mr. Smith and Mr. Fowler, in competition for the Society's undivided prize of 500*l.* This report will be published for the information of the members in the ensuing part of the Journal; in the mean time it is satisfactory to be able to state, that, although the conditions included in the terms of the prize have not been fulfilled by either of these inventions, Mr. Fowler has made considerable improvement in his application of steam-power to the operation of ploughing. The Council, in carrying out the arrangements for the Chelmsford Meeting, received the cordial and efficient co-operation of the Local Committee; and on that occasion, as on many former ones, the Society were under essential obligation to the different Railway Companies of the kingdom for the liberality of their concessions to the exhibitors, and the facilities they afforded in the transit of live-stock and implements to and from the Meeting.

The Country Meeting of next year will be held in the week commencing Monday, the 20th of July; and the authorities of Salisbury have already placed the land for the trial of implements under a due course of preparation. The Council have decided upon the following schedules of prizes to be offered by the Society for implements and live-stock at that meeting, subject to such terms and conditions of competition as the Council at their February Meeting may think it necessary to adopt.

1. *Implements.*

Class of drills	£30
„ manure-distributors (liquid or other)	20
„ horse-hoes	10
„ hay machines	10
„ reaping machines	20
„ mowing machines	20
„ horse-rakes	10
„ carts	10
„ waggons	10
„ carts of special construction, with specifications	15
Steam cultivator	500
	£655

2. *Live Stock.*

Short-horned cattle	£170
Hereford cattle	170
Devon cattle	170
Channel Islands' cattle	30
Cattle of other established breeds	45
Agricultural horses	130
Dray-horses	40
Thoroughbred, hunting, and hackney horses	105
Leicester sheep	110
Long-woolled sheep (not Leicesters)	110
Southdown sheep	110
Short-woolled sheep (not Southdowns)	110
Pigs	80
Farm poultry	120
	£1500

The Council continue to be favoured by the Earl of Clarendon with successive reports received at the Foreign Office from various countries abroad, in reference to the discovery of manuring substances in different parts of the world, and to the occurrence of epidemics of an infectious character among cattle.

The vigorous prosecution of agricultural research in every department of husbandry, and the more definite application of scientific reasoning to the elucidation of every branch of practical detail, as well as to the gradual establishment of general principles, are circumstances which constitute at the present day a still greater necessity for that division of labour on the one hand which the local societies throughout the kingdom are so competent to execute, and that unity of action on the other which can only be given by a great central body like the Royal Agricultural Society of England, which is at once the representative of the individual interests of the farming community, and the ready means by which their united energies may be most effectively brought into action for the purpose of gaining any given practical object. The increase of its members, and the estimation in which its labours are held, afford strong grounds for the belief that its usefulness will continue unimpaired, and its advantages become more widely distributed by a still further co-operation of the farmers of the country in the promotion of its national objects.

By order of the Council,

JAMES HUDSON, *Secretary.*

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

Half-Yearly Account, ending June 30, 1856.

Receipts during the half-year.

	£.	s.	d.
Balance in the hands of the Bankers, Jan. 1, 1856	884	3	10
Petty Cash Balance in the hands of the Secretary, Jan. 1, 1856	43	9	9
Dividends on Stock	129	14	1
Governors' Life-Compositions	90	0	0
Governors' Annual Subscriptions	460	0	0
Members' Life-Compositions	420	0	0
Members' Annual Subscriptions	3364	8	0
Journal Receipts	210	8	0
Country Meeting Receipts:—			
Chelmsford	1200	0	0
	£6802	3	8

Payments during the half-year.

	£.	s.	d.
Permanent Charges	165	0	0
Taxes and Rates	19	9	0
Establishment Charges	545	3	3
Postage and Carriage	35	17	10
Advertisements	4	3	6
Journal Payments	651	8	5
Veterinary Grant	100	0	0
Chemical Grant	150	0	0
Chemical Investigations	200	0	0
Country Meeting Payments:—			
Lincoln	108	15	6
Carlisle	716	12	8
Chelmsford	771	15	5
Subscriptions over-paid by Bankers returned	8	10	0
Sundry items of Petty Cash	3	0	6
Balance in the hands of the Bankers, June 30, 1856	3299	12	2
Petty Cash Balance in the hands of the Secretary, June 30, 1856	22	15	5
	£6802	3	8

(Signed) THOMAS RAYMOND BARKER, *Chairman*, C. B. CHALLONER, } *Finance Committee.*

Examined, audited, and found correct, this 12th day of Dec. 1856.

(Signed) GEORGE I. RAYMOND BARKER, GEORGE DYER, } *Auditors on the part of the Society.*

COUNTRY-MEETING ACCOUNT: CHELMSFORD, 1856.

RECEIPTS.

	£.	s.	d.
Subscription from Chelmsford	1200	0	0
Prizes offered by the Local Committee at Chelmsford	200	0	0
Non-Members' Fees for the entry of Live Stock	99	2	2
Non-Members' Fees for the entry of Implements	25	10	0
Implement-Exhibitors' payment, at half-price, for shedding required	342	10	0
Admissions to Show and Trial Yards	2988	8	5
Sale of Catalogues of Implements and Stock	334	13	0
Sale of Pavilion-Dinner Tickets	353	0	0
Sale of Council Badges	2	15	0
Excess of Payments over Receipts, on account of the Chelmsford Meeting, chargeable on the General Funds of the Society	1982	1	1
	£7527	19	8

(Signed) THOMAS RAYMOND BARKER, *Chairman*, } *Finance Committee.*
C. B. CHALLONER, }

PAYMENTS.

	£.	s.	d.
Show and Trial Yard Works, Poultry-Coops, Hurdles, Entrance-Turnstiles	2472	4	3
Extra Land, and Railway-platform Accommodation	25	0	0
Yardmen, Fieldmen, Clerks, Money-takers, Door-keepers, Catalogue-sellers	227	15	3
Judges of the Show	430	16	6
Judges' Refreshments	50	3	0
Veterinary-Inspector and Assistant	26	0	0
Consulting-Engineers at Chelmsford, Boxted, and Ipswich	131	17	5
New Dynamometer for draught of Field Implements	83	10	0
Hire of Farm Horses	99	5	0
Carriage of Boiler, Dynamometers, and Reaping Machines	8	18	11
Metropolitan Police	87	0	0
Green Food	92	3	6
Hay and Straw	117	14	6
Poultry Food	7	0	0
Coals, Clay, and Sand	3	18	0
Cordage, Hay-forks, Rakes, Hammers, and Nails	4	14	7
Stationery	21	1	10
Advertisements	151	16	6
Postage and Carriage	25	9	4
Programmes of the Meeting	5	9	0
Prize-sheets, Certificates, Labels, Admission-Orders, Circulars, Railway-Papers	210	2	6
Live-stock and Implement Catalogues	344	6	6
Live-stock and Implement Award-sheets	24	13	6
Prizes of the Society, awarded and paid	1600	11	3
Prizes of the Local Committee, awarded and paid	180	0	0
Prize of the Local Committee, not awarded	20	0	0
Pavilion-Building Contract (and extra-work, 27*l.* 11*s.*)	567	11	0
Pavilion-Dinner Contract	475	0	0
Pavilion Dinner Tickets, Toast Lists, Toastmaster, and Trumpeters	8	12	0
Badges for Council, Stewards, and Judges	6	6	4
Official Staff: Travelling Expenses, Board, and Lodging	16	17	0
Gratuity to Bankers' Clerk	2	2	0
	£7527	19	8

SHOW AT CHELMSFORD: JULY, 1856.

STEWARDS OF THE YARD.

Stewards of Cattle.

FRANCIS WOODWARD,
SIR STAFFORD NORTHCOTE, BT., M.P.
SAMUEL JONAS.

Stewards of Implements.

WILLIAM GEORGE CAVENDISH,
CHANDOS WREN HOSKYNS.
SIR ARCHIBALD MACDONALD, BT.

Steward of Farm-Poultry.

JOSEPH COOKE, Mayor of Colchester.

Honorary Director of the Show.

B. T. BRANDRETH GIBBS.

JUDGES.

Short-Horns.

JOHN GREY,
THOMAS PARKINSON,
ROBERT SMITH.

Herefords, Devons, and Other Breeds.

SAMUEL BLOXSIDGE,
WILLIAM TINDALL,
JOHN WILLIAMS.

Horses.

WILLIAM GREAVES,
JOHN WARSOP.

PATRICK GRAHAM BARNS,
WILLIAM CHARLES SPOONER.

Leicester Sheep.

WILLIAM HESSELTINE,
ROBERT SMITH,
WILLIAM TORR.

Southdown (or other Short-woolled) Sheep.

GEORGE BROWN,
HENRY CHAMBERLAIN,
PETER PURVES.

Long-woolled Sheep (not Leicesters).

ROBERT BOUGHEN AYLMER,
EDWARD LANE FRANKLIN,
NATH. CHAMBERLAIN STONE.

Pigs.

ARNOLD DENMAN,
CHARLES RANDALL,
THOMAS TROTTER.

Foreign Cattle.

EUGÈNE GAREAU (France),
DE VILLERS DE PITÉ (Netherlands),
DE GINGINS D'ECLEPEN (Switzerland).

Farm-Poultry.

GEORGE JAMES ANDREWS,
JOHN BAILY.

Implements.

HENRY BERNEY CALDWELL,
JOHN CLARKE,
WILLIAM CHALCRAFT,
JOHN VIRET GOOCH,
THOMAS HAWKINS,
THOMAS HUSKINSON,
JAMES HALL NALDER,
CLARE SEWELL READ,
JOHN JEPHSON ROWLEY,

Veterinary-Inspector.

PROFESSOR SIMONDS,
Royal Veterinary College.

Consulting-Engineer.

CHARLES EDWARDS AMOS
(Firm of EASTON and AMOS).

AWARD OF PRIZES.

CATTLE: *Short-horns.*

LIEUTENANT-COLONEL CHARLES TOWNELEY, of Towneley Park, Lancashire: the Prize of THIRTY SOVEREIGNS, for his 2 years and 11 months-old Roan Short-horned Bull "Master Butterfly;" bred by himself.

HENRY AMBLER, of Watkinson Hall, Halifax, Yorkshire, the Prize of FIFTEEN SOVEREIGNS, for his 3 years and 6 months-old Roan Short-horned Bull "Grand Turk;" bred by S. E. Bolden, of Springfield Hall, Lancaster.

FRANCIS HAWKESWORTH FAWKES, of Farnley Hall, Otley, Yorkshire: the Prize of TWENTY-FIVE SOVEREIGNS, for his 1 year 3 months and 16 days-old Roan Short-horned Bull "General Bosquet;" bred by himself.

MARK BARROBY, of Dishforth, Thirsk, Yorkshire, the Prize of FIFTEEN SOVEREIGNS, for his 1 year 10 months and 2 weeks-old White Short-horned Bull "Mark Anthony;" bred by himself.

HENRY AMBLER, of Watkinson Hall: the Prize of FIVE SOVEREIGNS for his 10 months-old Roan Short-horned Bull-calf "Napoleon;" bred by Walter Stead, of Leeds.

LIEUTENANT-COLONEL CHARLES TOWNELEY, of Towneley Park: the Prize of TWENTY SOVEREIGNS, for his 3 years and 9 months-old Roan Short-horned Cow "Duchess 2nd," In-milk and In-calf; bred by himself.

LIEUTENANT-COLONEL CHARLES TOWNELEY, of Towneley Park; the Prize of TEN SOVEREIGNS, for his 3 years and 10 months-old Red-and-White Short-horned Cow "Blanche 6th," In-milk and In-calf; bred by himself.

LIEUTENANT-COLONEL CHARLES TOWNELEY, of Towneley Park: the Prize of FIFTEEN SOVEREIGNS, for his 2 years and 8 months-old Roan Short-horned Heifer "Victoria," In-calf; bred by himself.

RICHARD STRATTON, of Broad-Hinton, Wiltshire: the Prize of TEN SOVEREIGNS, for his 2 years 5 months and 3 weeks-old Roan Short-horned Heifer "Marcia 3rd," In-calf; bred by himself.

RICHARD BOOTH, of Warlaby, Northallerton, Yorkshire: the Prize of TEN SOVEREIGNS, for his 1 year and 8 months-old Roan Short-horned Heifer "Queen of the May;" bred by himself.

CHARLES PASCOE GRENFELL, of Taplow Court, near Maidenhead: the Prize of FIVE SOVEREIGNS, for his 1 year and 5 months-old Red-and-White Short-horned Heifer "Bettine;" bred by himself.

CATTLE: *Herefords.*

LORD BERWICK, of Cronkhill, Salop: the Prize of THIRTY SOVEREIGNS, for his 3 years 5 months and 2 days-old Red (white-faced) Hereford Bull "Napoleon 3rd;" bred by himself.

EDWARD PRICE, of Court House, Pembridge, Herefordshire: the Prize of FIFTEEN SOVEREIGNS, for his 3 years and 11 months-old Red (white-faced) Hereford Bull "Goldfinder;" bred by John Perry, of Much-Cowan, Bromyard.

WILLIAM RACSTER, of Thinghill, Herefordshire: the Prize of TWENTY-FIVE SOVEREIGNS, for his 1 year and 9 months-old Red Hereford Bull "David Favourite Chance;" bred by himself.

EDWARD WILLIAMS, of Llowes Court, Radnorshire: the Prize of FIFTEEN SOVEREIGNS, for his 1 year and 9 months-old Dark-brown (white-faced) Hereford Bull "Radnor;" bred by himself.

WILLIAM PERRY, of Cholstrey, Herefordshire: the Prize of FIVE SOVEREIGNS, for his 10 months and 3 days-old Dark-red (white-faced) Hereford Bull-Calf "Cholstrey Boy;" bred by himself.

WILLIAM PERRY, of Cholstrey, Herefordshire: the Prize of TWENTY SOVEREIGNS, for his 3 years 8 months and 18 days-old Dark-red (white-faced) Hereford Cow "Carlisle Beauty," In-milk and In-calf; bred by himself.

PHILIP TURNER, of The Leen, Herefordshire: the Prize of TEN SOVEREIGNS, for his 4 years 9 months and 2 days-old Red (white-faced) Hereford Cow "Novice," In-milk and In-calf; bred by himself.

LORD BERWICK, of Cronkhill: the Prize of FIFTEEN SOVEREIGNS, for his 2 years 4 months and 3 days-old Red (white-faced) Hereford Heifer "Carlisle," In-calf; bred by himself.

WILLIAM RACSTER, of Thinghill: the Prize of TEN SOVEREIGNS for his 2 years 7 months and 5 days-old Red Hereford Heifer "David Thinghill Pigeon," In-milk; bred by himself.

WILLIAM RACSTER, of Thinghill, the Prize of TEN SOVEREIGNS, for his 1 year 8 months and 6 days old Red Hereford Heifer "Young Sir David Thinghill;" bred by himself.

WALTER MAYBERY, of Brecon: the Prize of FIVE SOVEREIGNS, for his 1 year and 11 months-old Brown (white-faced) Hereford Heifer "Fatima;" bred by himself.

CATTLE: *Devons.*

JOHN QUARTLY, of Champson-Molland, Devonshire: the Prize of THIRTY SOVEREIGNS, for his 3 years and 4 months-old Red Devon Bull "Sultan;" bred by himself.

WILLIAM M. GIBBS, of Bishop's-Lydeard, Somersetshire: the Prize of FIFTEEN SOVEREIGNS, for his 2 years and 6 months-old Red Devon Bull (without name); bred by himself.

HIS ROYAL HIGHNESS PRINCE ALBERT, of Windsor, Berkshire: the Prize of TWENTY-FIVE SOVEREIGNS, for his 1 year and 9 months-old Red Devon Bull "Zouave;" bred by George Turner, of Barton, near Exeter.

JOHN C. HALSE, of Molland, Devonshire: the Prize of FIFTEEN SOVEREIGNS, for his 1 year 4 months and 3 weeks-old Red Devon Bull "Earl of Essex;" bred by himself.

GEORGE TURNER, of Barton, near Exeter: the Prize of FIVE SOVEREIGNS, for his 6 months 2 weeks and 3 days-old Red Devon Bull-Calf "Bosquet;" bred by himself.

JAMES QUARTLY, of Molland House, Devonshire: the Prize of TWENTY SOVEREIGNS, for his 3 years and 6 months-old Red Devon Cow "Stately;" In-milk and In-calf; bred by himself.

WALTER FARTHING, of Stowey Court, Somersetshire: the Prize of TEN SOVEREIGNS, for his 3 years and 5 months-old Red Devon Cow "Fancy;" In-milk and In-calf; bred by himself.

JAMES QUARTLY, of Molland House: the Prize of FIFTEEN SOVEREIGNS, for his 2 years and 6 months-old Red Devon Heifer "Nonpareil," In-calf; bred by himself.

HIS ROYAL HIGHNESS PRINCE ALBERT, of Windsor, Berkshire: the Prize of TEN SOVEREIGNS, for his 2 years and 7 months-old Red Devon Heifer "Lubelia," In-calf; bred by George Turner, of Barton, near Exeter.

EDWARD POPE, of Great-Toller, Dorsetshire: the Prize of TEN SOVEREIGNS, for his 1 year and 7 months-old Red Devon Heifer "Fancy;" bred by himself.

JAMES HOLE, of Knowle House, Somersetshire: the Prize of FIVE SOVEREIGNS, for his 1 year and 5 months-old Red Devon Heifer (without name); bred by himself.

Cattle: *Other Breeds.*

Lord Sondes, of Elmham Hall, Norfolk: the Prize of Twenty Sovereigns, for his 2 years and 9 months-old Red Suffolk Bull "Red Jacket;" bred by G. D. Badham, of Ipswich.

James Singer Turner, of Chyngton Farm, Seaford, Sussex: the Prize of Ten Sovereigns, for his 3 years and 3 months-old Red Sussex Bull "Chyngton;" bred by himself.

G. D. Badham, of the Sparrow's Nest, Ipswich: the Prize of Ten Sovereigns, for his 1 year and 9 months-old Blood-red Suffolk Bull (without name); bred by himself.

James Gorringe, of Tilton-Selmeston, Lewes: the Prize of Ten Sovereigns, for his 5 years and 7 months-old Red Sussex Cow "Eva," In-milk and In-calf; bred by himself.

Thomas Moore Hudson, of Castleacre, near Swaffham, Norfolk: the Prize of Five Sovereigns, for his 5 years and 10 months-old Red Suffolk Cow "Gay Lass;" bred by the late Sir Edward Kerrison, Bart., of Oakley Park, near Eye.

Lord Sondes, of Elmham Hall: the Prize of Ten Sovereigns, for his 2 years and 8 months-old Red Suffolk Heifer "Minna," In-calf; bred by himself.

G. D. Badham, of the Sparrow's Nest: the Prize of Five Sovereigns, for his 1 year and 6 months-old Blood-red Suffolk Heifer (without name); bred by himself.

Foreign Cattle.

Comte de Bouillé, au Château de Villars, par Magny-Cours, Département de la Nièvre, France: the Prize of Thirty Sovereigns, for his 22 months-old White Charolais Bull "Tracthir;" bred by himself.

M. Cheradame, Propriétaire à Ecouchi, Département de l'Orne: the Prize of Twenty-five Sovereigns, for his 39 months-old "Payne's-grey" Norman Bull; bred by M. Leboucher, of Vrigny, in the Department of the Orne.

M. Ris. Allier, Directeur-Fondateur de la Colonie de Petit-Bourg, en France: the Prize of Twenty Sovereigns, for his 6 years-old black-and-white Brittany Bull "Tom Puce;" bred by himself.

M. Eluard, Propriétaire à Vert-St.-Denis, Département de la Seine et Marne: the Prize of Fifteen Sovereigns, for his 26 months-old trout-speckled Norman Bull; bred by M. Surcin, à Nogent-le-Rotrou, Département de l'Eure et Loire.

M. Philippe, Propriétaire à Grisoller, Département de l'Ain: the Prize of Ten Sovereigns, for his 30 months-old dapple-white Norman Bull; bred by M. Sanaux, à Neufchâtel en Saonnais.

Comte de Bouillé, au Château de Villars: the Prize of Twenty Sovereigns, for his 38 months-old White In-calf Charolaise Cow "Fadette;" bred by himself.

M. Eluard, Propriétaire à Vert-St.-Denis: the Prize of Fifteen Sovereigns, for his 48 months-old trout-speckled Norman Cow; bred by M. Noel Morin, à Cohagne, près Villers-Bocage, Département du Calvados.

M. Ris. Allier, Directeur-Fondateur de la Colonie Agricole de Petit-Bourg: the Prize of Ten Sovereigns, for his 26 months and 22 days-old black-and-white Brittany Cow "Rosa Bonheur;" bred by himself.

M. Dutrône, Conseiller-Honoraire, à Trousseauville, Département du Calvados; the Prize of Five Sovereigns, for his Polled Norman Cow; bred by himself.

[This prize was not received at the Chelmsford Meeting by M. Dutrône, who desired that it might be reserved for his disposal until certain arrangements which he had then in contemplation, with reference to polled cattle generally, should be completed.

There was no competition for the sixth prize of 5*l.* for Foreign Bulls; nor for the prizes also offered by the Society for Foreign Sheep, amounting to 115*l.*

In addition to the money-prize, a Silver Medal was presented by the Society to each of the successful foreign candidates at the Chelmsford Meeting.]

HORSES.

HIS ROYAL HIGHNESS PRINCE ALBERT, of Windsor, Berkshire: the Prize of THIRTY SOVEREIGNS, for his 5 years-old Brown Clydesdale Stallion "Britain," for agricultural purposes; bred by Robert Findlay, of Easter-hill, near Glasgow.

MANFRED BIDDELL, of Playford, Ipswich: the Prize of TWENTY SOVEREIGNS, for his 4-years old Chesnut Suffolk Stallion "Major," for agricultural purposes; bred by himself.

G. M. SEXTON, of Earl's Hall, near Sudbury, Suffolk: the Prize of TWENTY SOVEREIGNS, for his 2 years-old Chesnut Suffolk Stallion "Boxer," for agricultural purposes; bred by James Josselyn, of Copdock, near Ipswich.

G. D. BADHAM, of the Sparrow's Nest: the Prize of TEN SOVEREIGNS, for his 2 years and 3 months-old Chesnut Suffolk Stallion "Napoleon," for agricultural purposes; bred by himself.

SAMUEL CLAYDEN, of Little Linton, Cambridgeshire: the Prize of FIFTEEN SOVEREIGNS, for his 1 year-old Chesnut Suffolk Stallion (without name) for agricultural purposes; bred by himself.

GEORGE CARTER, of Danbury, Essex: the Prize of TWENTY SOVEREIGNS, for his 4 years-old Bright-chesnut Suffolk Mare "Primrose" and her Foal, for agricultural purposes; bred by J. Blanchflower, of Mayland, Essex.

NATHANIEL GEORGE BARTHROPP, of Cretingham Rookery, Woodbridge, Suffolk: the Prize of TEN SOVEREIGNS, for his 15 years-old Chesnut Suffolk Mare "Darby of Exeter" and her Foal, for agricultural purposes; bred by himself.

SAMUEL WRINCH, of Great Holland, Essex: the Prize of FIFTEEN SOVEREIGNS, for his 2 years-old Chesnut Suffolk Filly (without name) for agricultural purposes; bred by himself.

SAMUEL CLAYDEN, of Little Linton: the Prize of TEN SOVEREIGNS, for his 2 years-old Chesnut Suffolk Filly (without name) for agricultural purposes; bred by himself.

WILLIAM BAKER and SON, of Bury Farm, Stapleford, Cambridgeshire: the Prize of TWENTY SOVEREIGNS, for their 3 years and 3 months-old Iron-grey Dray Stallion "Young Inkermann;" bred by Peter Grain, jun., of Shelford, Cambridgeshire.

CHARLES TIMM, M.D., of Scrooby House, near Bawtry: the Prize of FIFTEEN SOVEREIGNS, for his 2 years and 22 days-old Roan Dray Stallion "Great Northern;" bred by himself.

[There was no competition for the Prizes of TEN and FIVE SOVEREIGNS respectively offered for Mares with their Foals, and for Fillies.]

SHEEP: *Leicesters.*

THOMAS EDWARD PAWLETT, of Beeston, Bedfordshire: the Prize of TWENTY-FIVE SOVEREIGNS, for his 16 months-old Shearling Ram; bred by himself.

THOMAS EDWARD PAWLETT, of Beeston: the Prize of FIFTEEN SOVEREIGNS, for his 16 months-old Shearling Ram; bred by himself.

THOMAS EDWARD PAWLETT, of Beeston: the Prize of TWENTY-FIVE SOVEREIGNS, for his 40 months-old Ram; bred by himself.

ROBERT WARD CRESSWELL, of Ravenstone, Leicestershire: the Prize of FIFTEEN SOVEREIGNS, for his 28 months-old Ram; bred by himself.

JOHN GREGORY WATKINS, of Woodfield, Worcestershire: the Prize of TWENTY SOVEREIGNS, for his Pen of five 16 months-old Shearling Ewes; bred by himself.

GEORGE TURNER, of Barton, near Exeter: the Prize of TEN SOVEREIGNS, for his Pen of five 16 months-old Shearling Ewes; bred by himself.

SHEEP: *Southdowns.*

HENRY OVERMAN, of Weasenham, Norfolk: the Prize of TWENTY-FIVE SOVEREIGNS, for his 16 months-old Shearling Ram; bred by himself.

JONAS WEBB, of Babraham, Cambridgeshire: the Prize of FIFTEEN SOVEREIGNS, for his 16 months-old Shearling Ram; bred by himself.

LORD WALSINGHAM, of Merton Hall, Norfolk: the Prize of TWENTY-FIVE SOVEREIGNS, for his 27½ months-old Ram "Merton;" bred by himself.

LORD WALSINGHAM, of Merton Hall: the Prize of FIFTEEN SOVEREIGNS, for his 27½ months-old Ram "Raglan;" bred by himself.

LORD WALSINGHAM, of Merton Hall: the Prize of TWENTY SOVEREIGNS, for his Pen of five 15½ months-old Shearling Ewes; bred by himself.

LORD WALSINGHAM, of Merton Hall: the Prize of TEN SOVEREIGNS, for his Pen of five 15½ months old Shearling Ewes; bred by himself.

SHEEP: *Long-wools (not Leicesters).*

JAMES WALKER, of Northleach, Gloucestershire: the Prize of TWENTY-FIVE SOVEREIGNS, for his 16 months-old Shearling Long-woolled Ram; bred by himself.

THOMAS BEALE BROWNE, of Hampen, Andoversford, Gloucestershire: the Prize of FIFTEEN SOVEREIGNS, for his 15½ months-old Shearling Cotswold Ram; bred by himself.

WILLIAM LANE, of Broadfield Farm, Northleach, Gloucestershire: the Prize of TWENTY-FIVE SOVEREIGNS, for his 28 months-old Cotswold Ram; bred by himself.

WILLIAM GARNE, jun., of Killkenny Farm, Fairford, Gloucestershire: the Prize of FIFTEEN SOVEREIGNS, for his 39 months-old Cotswold Ram; bred by himself.

WILLIAM LANE, of Broadfield Farm: the Prize of TWENTY SOVEREIGNS, for his Pen of five 16 months-old Shearling Cotswold Ewes; bred by himself.

WILLIAM LANE, of Broadfield Farm: the Prize of TEN SOVEREIGNS, for his Pen of five 16 months-old Shearling Cotswold Ewes: bred by himself.

PIGS.

The Rev. CHARLES THOMAS JAMES, of Ermington, Ivybridge, Devonshire: the Prize of TEN SOVEREIGNS, for his 2 years and 7 months-old Berkshire Boar "Gipsy Boy;" black with white spots, of the large breed; bred by J. William Hewer, of Sevenhampton.

JOHN HARRISON, jun., of Heaton-Norris, Stockport, Lancashire: the Prize of FIVE SOVEREIGNS, for his 2 years 3 months and 3 weeks-old White Boar "Young Albert," of the large breed; bred by J. Cooper, of Whaley.

THOMAS CRISP, of Chillesford Lodge, Suffolk: the Prize of TEN SOVEREIGNS, for his 1 year and 1 month-old Black Boar (without name), of the small breed; bred by himself.

RICHARD ENGLAND, of Arthington, Otley, Yorkshire: the Prize of FIVE SOVEREIGNS, for his 1 year 4 months and 2 weeks-old White Boar "Wharfdale Prince," of the small breed; bred by himself.

W. B. WAINMAN, of Carhead, Cross Hills, Yorkshire: the Prize of TEN SOVEREIGNS, for his 3 years 4 months and 1 week-old White Breeding Sow (without name), of the "Improved Yorkshire" large breed; bred by himself.

HENRY SCOTT HAYWARD, of Folkington, Willingdon, Sussex: the Prize of TEN SOVEREIGNS, for his 1 year-old White Breeding-Sow "Polyanthus," of the Sussex small breed; bred by himself.

The Rev. CHARLES THOMAS JAMES, of Ermington: the Prize of TEN SOVEREIGNS, for his Pen of three 6 months and 27 days-old Breeding Sow-pigs, of the "Improved Berkshire" large breed, black with white spots; bred by himself.

R. H. WATSON, of Bolton Park, Wigton, Cumberland: the Prize of TEN SOVEREIGNS, for his Pen of three 7 months and 3 weeks-old White Breeding Sow-pigs "Friendship," "Love," and "Truth," of the small breed; bred by himself.

FARM POULTRY: *Dorkings.*

CAPTAIN HORNBY, R.N., of Knowsley Cottage, Prescot: the Prize of FIVE SOVEREIGNS, for his 5 months and 3 weeks-old Grey Dorking Chickens of 1856; bred by himself.

The Rev. THOMAS LYON FELLOWES, of Beighton Rectory, Norfolk: the Prize of THREE SOVEREIGNS, for his 5 months and 3 weeks old Grey Dorking Chickens of 1856; bred by James Lewry, of Handcross.

GEORGE GODFREY, of Aylesbury: the Prize of TWO SOVEREIGNS, for his 4 months-old Grey Dorking Pullets and 5 months-old Grey Dorking Cock; bred by Mrs. Seamons, of Hartwell.

JAMES FROST, of Parham, Suffolk: the Prize of ONE SOVEREIGN, for his Coloured Dorking Chickens of 1856; bred by himself.

CAPTAIN HORNBY, R.N., of Knowsley Cottage: the Prize of FIVE SOVEREIGNS, for his (about) 2 years-old Grey Dorking Fowls; bred by himself.

G. BOTHAM, of Wexham Court, Bucks: the Prize of THREE SOVEREIGNS, for his 2 years-old Rose-combed Dorking Fowls; breeder unknown.

WILLIAM TOD, of Elphinstone Tower, Haddingtonshire: the Prize of TWO SOVEREIGNS, for his 1 year and 5 months-old Grey Dorking Fowls; bred by himself.

The Rev. MORTON SHAW, of Rougham Rectory, Bury-St.-Edmund's: the Prize of ONE SOVEREIGN, for his Single-combed Grey Dorking Fowls; the Cock 1 year 1 month and 2 weeks old, and bred by J. Ullock of Quarry Lowe; the hens 1 year 2 months and 3 weeks old, and bred by the exhibitor.

EDWARD AKROYD, of Denton Park, Otley, Yorkshire: the Prize of TWO SOVEREIGNS, for his (about) 2 years and 3 months-old Silver, or Grey, Dorking Cock; breeder unknown.

WILLIAM FISHER HOBBS, Boxted Lodge, Colchester: the Prize of ONE SOVEREIGN, for his (more than) 1 year-old Dorking Cock; bred by himself.

FARM POULTRY: *Spanish Fowls.*

CAPTAIN HORNBY, R.N., of Knowsley Cottage: the Prize of FIVE SOVEREIGNS, for his (about) 2 years-old Black Spanish Fowls; breeder unknown.

The Rev. MORTON SHAW, of Rougham Rectory: the Prize of THREE SOVEREIGNS, for his 1 year and 2 months-old Spanish Fowls; bred by himself.

JOHN BUNCOMBE, of Wellington, Somersetshire: the Prize of TWO SOVEREIGNS, for his 1 year and 2 weeks-old Black White-faced Spanish Fowls; bred by W. W. Brundritt, of Runcorn.

THOMAS STUBBINGS, of Broomfield, Chelmsford: the Prize of ONE SOVEREIGN, for his Spanish Fowls; the age of the Cock and one Hen 1 year and 2 weeks, that of the other Hen 2 years and 2 months; bred by himself.

The Rev. MORTON SHAW, of Rougham Rectory: the Prize of TWO SOVEREIGNS, for his 1 year and 2 months-old Spanish Cock; bred by himself.

Farm Poultry: *Cochin-China Fowls.*

Mrs. Parker, of Coatslaith, Brampton, Cumberland: the Prize of Four Sovereigns, for her 4 months-old Buff Cochin-China Chickens of 1856; bred by herself.

The Rev. Grenville Frodsham Hodson, of North Petherton, Somersetshire: the Prize of Two Sovereigns, for his 4 months-old Partridge Cochin-China Chickens of 1856; bred by himself.

Charles Punchard, of Blunt's Hall, Suffolk: the Prize of Four Sovereigns, for his (more than) 1 year-old Buff and Cinnamon Cochin-China Fowls; breeder unknown.

The Rev. Grenville Frodsham Hodson, of North Petherton: the Prize of Two Sovereigns, for his (about) 2 years-old Partridge Cochin-China Fowls; the breeder of the Cock unknown; the Hens bred by G. Philip Paige.

Thomas Hincks, of Pennfield, Wolverhampton: the Prize of Two Sovereigns, for his 2 years-old Buff Cochin-China Cock; breeder unknown.

Farm Poultry: *Brahma-Pootras.*

Richard Postans, of Shelly, Suffolk: the Prize of Two Sovereigns, for his 13 months-old light-coloured Brahma-Pootra Fowls; bred by himself.

Farm Poultry: *Game Fowls.*

Captain Hornby, R.N., of Knowsley Cottage: the Prize of Five Sovereigns, for his (about) 2 years-old Red Game Fowls; bred by himself.

Edward Glover, of Olton Green, Warwickshire: the Prize of Three Sovereigns, for his 2 years and 1 month-old Black-breasted Red Game Fowls; bred by himself.

G. C. Adkins, of West House, Birmingham: the Prize of Two Sovereigns, for his (about) 2 years-old Red Game Fowls; breeder unknown.

Henry Thurnall, of Royston, Cambridgeshire: the Prize of One Sovereign, for his 2 years 2 months and 3 weeks-old Birchen-yellow Game Fowls; bred by himself.

N. N. Dyer, of Manor House, Bredon, Tewkesbury: the Prize of Two Sovereigns, for his 1 year and 1 month-old Black-breasted Red Game Cock; bred by himself.

Farm Poultry: *Hamburg Fowls.*

John Lowe, of Bull Ring, Birmingham: the Prize of Two Sovereigns, for his Golden-pencilled Hamburg Fowls, the Cock 10 months and the Hens 14 months old; bred by himself.

James Dixon, of North Park, Bradford, Yorkshire: the Prize of One Sovereign, for his Golden-pencilled Hamburg Fowls, the Cock 2 years and the Hens 1 year-old; bred by himself.

James Dixon, of North Park: the Prize of Two Sovereigns, for his Silver-pencilled Hamburg Fowls, the Cock 2 years and the Hens 1 year-old; bred by himself.

The Rev. Thomas Lyon Fellowes, of Beighton Rectory: the Prize of One Sovereign, for his Silver-pencilled Hamburg Fowls, the Cock 1 year and the Hens 1 year and 3 months old; bred by himself.

James Dixon, of North Park: the Prize of Two Sovereigns, for his 2 years-old Golden-spangled Hamburg Fowls; bred by himself.

James Dixon, of North Park: the Prize of One Sovereign, for his 2 years-old Golden-spangled Hamburg Fowls; bred by himself.

James Dixon, of North Park; the Prize of Two Sovereigns, for his Silver-spangled Hamburg Fowls, the Cock 2 years and the Hens 1 year old; bred by himself.

W. B. Mapplebeck, of Bull Ring, Birmingham: the Prize of One Sovereign, for his 2 years-old Silver-spangled Hamburg Fowls; bred by Miss Mary Ann Tuley, of Keighley, Yorkshire.

Farm Poultry: *Malay Fowls.*

John Buncombe, of Wellington, Somersetshire: the Prize of Two Sovereigns, for his 2 years-old Black-breasted Red Malay Fowls; bred by Miss King and Charles Ballance, of Taunton.

Farm Poultry: *Poland Fowls.*

R. H. Bush, of Ashton Lodge, Bath: the Prize of Four Sovereigns, for his (above) 2 years-old Golden-Poland Fowls: bred by himself.

R. H. Bush, of Ashton Lodge: the Prize of Two Sovereigns, for his Golden-Poland Fowls, the Cock 4 years and the Hens 2 years-old; bred by himself.

Charles Edmund Coleridge, of Eton: the Prize of Four Sovereigns, for his Silver-Poland Fowls; the Cock over 3 years, and the Hens respectively 2 years, and 1 year and 1 month old; the Cock bred by E. Strange, of Ampthill, and the Hens by the Exhibitor.

G. C. Adkins, of West House, Edgbaston, Birmingham: the Prize of Two Sovereigns, for his 2 years-old Silver-Poland Fowls; breeder unknown.

G. C. Adkins, of West House: the Prize of Four Sovereigns, for his (about) 2 years-old White-crested Black Poland Fowls; breeder unknown.

Charles Edmund Coleridge, of Eton: the Prize of Two Sovereigns, for his 2 years and 3 months-old White Poland Fowls; the Cock bred by F. Edwards, of Balstrode Park, Gerrard's Cross, and the Hens by the Exhibitor.

[No entries were made for the Prizes offered by the Society for *Turkeys* or *Geese*.]

Farm Poultry: *Aylesbury Ducks.*

John Weston, of Aylesbury: the Prize of Three Sovereigns, for his 5 months and 1 week-old Aylesbury Drake and two Ducks; bred by himself.

John Weston, of Aylesbury: the Prize of Two Sovereigns, for his 2 months and 1 week-old Aylesbury Drake and two Ducks; bred by himself.

John Weston, of Aylesbury: the Prize of One Sovereign, for his 6 months and 2 weeks-old Aylesbury Drake and two Ducks; bred by himself.

Farm Poultry: *Rouen Ducks.*

John Weston, of Aylesbury: the Prize of Three Sovereigns, for his 2 months and 3 weeks-old Rouen Drake and two Ducks; bred by himself.

The Rev. Thomas Lyon Fellowes, of Beighton Rectory: the Prize of Two Sovereigns, for his (under) 3 months-old Brown Rouen Drake and two Ducks; bred by himself.

Charles Punchard, of Blunt's Hall: the Prize of One Sovereign for his 4 months-old Rouen Drake and two Ducks; bred by himself.

Farm Poultry: *Other Ducks.*

James Dixon, of North Park: the Prize of Two Sovereigns, for his 1 year and 1 month-old Black East-Indian Drake and two Ducks; bred by himself.

William Fisher Hobbs, of Boxted Lodge, Colchester: the Prize of One Sovereign, for his (more than) 1 year-old "Improved Essex" Drake and two Ducks; bred by himself.

Special Prizes

OFFERED BY THE CHELMSFORD LOCAL COMMITTEE.

ROBERT and JAMES MOFFAT, of Newtown-of-Rockliffe, Cumberland: the Prize of THIRTY SOVEREIGNS, for their 16 years-old dark-brown thoroughbred Stallion "A British Yeoman;" bred by J. Blacklock, of Harts, Yorkshire; sire "Liverpool," dam "Fancy," sire of dam "Ousemeed."

SAMUEL ADAMS, of Great Waltham, Essex: the Prize of THIRTY SOVEREIGNS, for his (from 12 to) 14 years-old Brown thoroughbred Hunter-Stallion "Tom Moody;" breeder not stated; sire "The Flyer," dam "Ladybird," sire of dam "Smolensko."

GEORGE RAYSON, of Highhead Castle Farm, Carlisle: the Prize of TWENTY-FIVE SOVEREIGNS, for his 5 years-old Bay Coaching-Stallion "Scrivington;" bred by J. Howston, of Low Dike, Cumberland; sire "Hambleton Hero," dam not stated, sire of dam "Splendour."

WILLIAM JEX, of Hopton, Suffolk: the Prize of TWENTY-FIVE SOVEREIGNS, for his 5 years-old Bay Riding or Hackney Stallion "Sebastopol;" bred by S. G. Bately, of Southtown, Great Yarmouth: sire "Tom Moody," dam unknown, sire of dam "Lamplighter."

[The Judges withheld the Prize of 20*l.* for the Weight-carrying Hunter Mare.]

The Rev. CHARLES THOMAS JAMES, of Ermington, Ivybridge, Devonshire: the Prize of TWENTY SOVEREIGNS, for his 8 years-old Brown Hackney Mare "Gaiety;" breeder not stated.

FREDERICK BARLOW, of the Shrubbery, Hasketon, Suffolk: the Prize of FIFTEEN SOVEREIGNS, for his 5 years-old Black-brown Hunter-Gelding; breeder not stated.

The EARL OF DARNLEY, of Cobham Hall, Kent: the Prize of TEN SOVEREIGNS for his 2 years-old Chesnut Hunter-Gelding; bred by himself.

FRANCIS BARKER, of Westland, Essex: the Prize of FIFTEEN SOVEREIGNS, for his 7 years-old Bay Hackney-Gelding "Safety;" breeder unknown.

FREDERICK BARLOW, of the Shrubbery: the Prize of TEN SOVEREIGNS, for his 2 years-old Bay Hackney-Gelding; breeder not stated.

Commendations.

The mark * signifies "HIGHLY COMMENDED;" the mark † "COMMENDED" (distinctly and individually); and the omission of these marks, "GENERALLY COMMENDED" (as part of a whole class).

†JAMES HAUGHTON LANGSTON, M.P., of Sarsden House, Chipping-Norton: for his 3 years and 9 months-old Red-and-White Short-horned Bull "Field-Marshal;" bred by himself.

†LORD FEVERSHAM, of Duncombe Park, Helmsley: for his 3 years and 3 months-old Red-and-White Short-horned Bull "Fifth Duke of Oxford;" bred by the late Earl of Ducie.

†LORD FEVERSHAM, of Duncombe Park: for his 3 years and 2 months-old Red-and-White Short-horned Bull "Gloucester;" bred by the late Earl of Ducie.

*JAMES REA, of Monaughty, Knighton: for his 1 year 5 months 2 weeks and 1 day-old Dark-red White-faced Hereford Bull (without name); bred by himself.

*JOHN WALKER, of Westfield House, Holmer: for his (about) 9 years-old Brown White-faced Hereford Cow, In-milk (without name); breeder not known.

*WALTER MAYBERY, of Brecon: for his 1 year and 9 months-old Brown White-faced Hereford Heifer "Gladys;" bred by himself.

†WILLIAM TAYLOR, of Showle Court, Hereford: for his 3 years and 6 months-old Red White-faced Hereford Bull "Triton;" bred by himself.

†William Fisher Hobbs, of Boxted Lodge, Colchester: for his 11 months-old Red White-faced Bull-calf "Napoleon;" bred by himself.

William Styles Powell, of Hereford: for his 1 year and 11 months-old Red-Brown White-faced Hereford Heifer "The last Duchess of Newton;" bred by the late David Williams, of Newton-Seethrog.

Edward Price, of Court House, Pembridge: for his 1 year and 11 months-old Red White-faced Hereford Heifer "Lady Wallace;" bred by himself.

Edward Price, of Court House: for his 1 year and 4 months-old Brown White-faced Hereford Heifer "Lady Bruce;" bred by himself.

His Royal Highness Prince Albert, of Windsor Castle: for his 1 year and 10 months-old Red White-faced Hereford Heifer "Hedgehog;" bred by the Earl of Radnor, of Coleshill.

His Royal Highness Prince Albert, of Windsor Castle: for his 1 year and 11 months-old Red White-faced Hereford Heifer "Vienna;" bred by the Earl of Radnor.

William Stedman, of Bedstone Hall, Ludlow: for his 1 year 6 months and 11 days-old Red White-mane-and-faced Hereford Heifer "Miss Curly;" bred by himself.

William Stedman, of Bedstone Hall: for his Red White-mane-and-faced Hereford Heifer "Miss Berry;" bred by himself.

James Rea, of Monaughty: for his 1 year 6 months 3 weeks and 5 days-old Red and Grey White-faced Hereford Heifer (without name); bred by himself.

Philip Turner, of the Leen, Pembridge: for his 1 year 8 months and 13 days-old Red White-faced Hereford Heifer "Graceful;" bred by himself.

*Walter Farthing, of Stowey Court, Bridgewater: for his 3 years and 3 months-old Red Devon Bull "Ben;" bred by himself.

*Richard Corner, of Torweston, Taunton: for his 1 year and 7 months-old Red Devon Bull "Weston;" bred by himself.

*William M. Gibbs, of Bishop-Lydeard, Taunton: for his 6 years and 8 months-old Red Devon Cow "Daisy," In-milk and In-calf; bred by himself.

*James Quartly, of Molland House, Southmolton: for his 6 years and 6 months-old Red Devon Cow "Rosebud," In-milk and In-calf; bred by himself.

*John C. Halse, of Molland, Southmolton: for his 7 years and 5 months-old Red Devon Cow "Fancy," In-calf and In-milk; bred by Thomas Halse.

His Royal Highness Prince Albert, of Windsor Castle: for his 2 years and 6 months-old Red Devon Heifer "Rosa," In-calf; bred by the Earl of Aylesford, of Packington.

Thomas Miller, of Castle Farm, Sherborne: for his 2 years and 4 months-old Red Devon Heifer "Moss-Rose," In-calf; bred by himself.

Thomas Miller, of Castle Farm: for his 2 years and 4 months-old Red Devon Heifer "Red Rose," In-calf; bred by himself.

Edward Pope, of Great Toller, Maiden Newton: for his 2 years and 6 months-old Red Devon Heifer "Matchless," In-calf; bred by himself.

James Quartly, of Molland House: for his 2 years and 6 months-old Red Devon Heifer "Moss-Rose," In-calf; bred by himself.

James Quartly, of Molland House: for his 2 years and 3 months-old Red Devon Heifer "Nectar," In-calf; bred by himself.

*T. B. Hildyard, of Flintham Hall, Newark: for his 5 years-old Grey Agricultural Stallion "Matchless;" bred by J. Hatoe, of Sempringham Fen, Folkingham.

*Samuel and Robert Spencer, of Flecknoe, Daventry: for their 2 years-old Brown-roan Cart-Stallion "Carlisle;" bred by Robert Cowley, of Kilsby, Rugby.

*Matthew Berridge, of Ingarsby, Leicester: for his 1 year-old Black Dishley-Leicestershire Agricultural Stallion (without name); bred by Thomas Willey, of Houghton-on-the-Hill, Leicestershire.

*Charles Cordy, of Frimley-St.-Mary, Ipswich: for his 6 years-old Chesnut Suffolk Mare "Matchet," and foal, for Agricultural purposes; bred by himself.

*His Royal Highness Prince Albert, of Windsor Castle: for his 2 years-old Brown Clydesdale Filly "Mary," for Agricultural purposes; bred by William Menzies, of Inch Farm, Kincardine-on-Forth.

††Ferdinand Robbe Duchateau, Propriétaire-Cultivateur, à Hames-Boucres, Canton de Guînes: for his large 5 years-old Dapple-Grey Boulogne Agricul-

tural Stallion "Joli-cœur;" bred by M. Dubos, Propriétaire-Cultivateur à Marguise:—*specially commended by the Judges as a specimen of a French horse.*

††FERDINAND ROBBE DUCHATEAU, à Hames-Boucres: for his 7 years-old large Dapple-Grey Boulogne Agricultural Stallion "Ferdinand;" bred by M. Hubert Codron, Propriétaire-Cultivateur, à Frethun;—*specially commended by the Judges as a specimen of a French horse.*

†NATHANIEL GEORGE BARTHROPP, of Cretingham Rookery, Woodbridge: for his 8 years-old Chesnut Suffolk Stallion "Hercules," for Agricultural purposes: bred by D. Green, of Fenringhoo, Colchester.

†JOHN L. WILLES, of Fillingham, Maldon: for his 8 years-old Chesnut half-bred Suffolk Stallion "Constitution," for Agricultural purposes; bred by himself.

†GEORGE JOHN RUST, of Great Leighs, Chelmsford: for his 6 years-old Bay Agricultural Stallion "Young Heart of Oak;" bred by J. Bentall, of Felsted, Braintree.

†WILLIAM BULLER, of Hanwell Fields, Banbury: for his 5 years-old Brown Oxfordshire Agricultural Stallion "Conqueror;" bred by John White.

†EDWARD ROBERT BLEWITT, of Bushey, Watford: for his 4 years-old Black Agricultural Stallion "Black Prince;" bred by J. Badrick, of Bierton, Aylesbury.

†JOHN COULSON, of Icklingham, Mildenhall: for his 3 years-old Chesnut Cart-Stallion "George;" bred by himself.

†SAMUEL SPARSHATT, of Weston Farm, Odiham: for his 2 years-old Bay Agricultural Stallion (without name); bred by himself.

†JOHN WILLIAMS, of Frimley-St.-Martin, Ipswich: for his 2 years-old Chesnut Suffolk Stallion "Champion," for Agricultural purposes; bred by himself.

†SAMUEL WOLTON, JUN., of Kesgrave, Woodbridge: for his 2 years-old Chesnut Suffolk Filly "Duchess," for Agricultural purposes; bred by himself.

†JOHN WARD, of East-Mersea, Colchester: for his 2 years-old Chesnut Suffolk Filly (without name), for Agricultural purposes; bred by Robert Harris, of Culpho, Ipswich.

†EDWARD HOLLAND, M.P., of Dumbleton Park, Evesham: for his 2 years-old Bay Gloucestershire Filly "Graceful," for Agricultural purposes; bred by himself.

JOHN WILLIAMS, of Frimley-St.-Martin, Ipswich: for his 2 years-old Chesnut Suffolk Filly "Doubty," for Agricultural purposes; bred by himself.

SAMUEL WOLTON, JUN., of Kesgrave, Woodbridge: for his 2 years-old Chesnut Suffolk Filly "Countess," for Agricultural purposes; bred by himself.

SAMUEL WOLTON, JUN., of Kesgrave: for his 2 years-old Chesnut Suffolk Filly "Princess," for Agricultural purposes; bred by J. Meller, of Clopton, Woodbridge.

G. D. BADHAM, of The Sparrow's Nest, Ipswich: for his 2 years-old Chesnut Filly (without name), for Agricultural purposes; bred by himself.

RICHARD WOODMAN, of Glynde, Lewes: for his 2 years and 2 months-old Chesnut Suffolk Filly (without name), for Agricultural purposes; bred by himself.

N. G. BARTHROPP, of Cretingham Rookery: for his 2 years-old Chesnut Suffolk Filly (without name), for Agricultural purposes; bred by himself.

HIS ROYAL HIGHNESS PRINCE ALBERT, of Windsor Castle: for his 2 years old Bay Clydesdale Filly "Sally," for Agricultural purposes; bred by himself.

THOMAS BRIDGE, of Buttsbury, Ingatestone; for his 2 years and 1 month-old Bay home-breed Agricultural Filly (without name); bred by William Chaffey, of Tednarnbury, Sawbridgeworth.

J. B. OWEN, of Hodcott, Newbury: for his 2 years and 1 month-old Black Berkshire Agricultural Filly; bred by himself.

†THOMAS EDWARD PAWLETT, of Beeston: for his 16 months-old Leicester Shearling Ram; bred by himself.

†ROBERT WARD CRESSWELL, of Ravenstone, Ashby-de-la-Zouch; for his 16 months-old Leicester Shearling Ram; bred by himself.

†JOHN GARNE, of Filkins, Lechlade: for his 39 months-old Long-wool or Cotswold Ram; bred by the late Charles Large, of Broadwell.

†GEORGE FLETCHER, of Shipton, Andoversford: for his 28 months-old Cotswold Ram; bred by himself.

†THOMAS WALKER, of Yanworth, Northleach: for his 15 months-old Pen of five Shearling Long-wool or Cotswold Ewes; bred by himself.

†*George Mangles, of Givendale, Ripon: *specially highly-commended*, for his 3 years and 11 months-old White Yorkshire Breeding-Sow "Queen of Hearts," of the small breed; bred by himself.

*John Harrison, jun., of Heaton-Norris, Stockport: for his 10 months 1 week and 6 days-old White Boar "Young Prince," of the small breed; bred by J. Downs, of Reddish, Stockport.

*James Marriott, of Floore, Weedon: for his 6 months-old White Improved-Leicester and Yorkshire Boar "Raglan," of the small breed; bred by himself.

*Henry Blandford, of Sandridge, Chippenham: for his 3 years 2 months and 3 weeks-old Berkshire Breeding-Sow "Lady Betty," black, with white face and feet and a few spots, of the large breed; bred by himself.

*The Rev. Charles Thomas James, of Ermington, Ivybridge: for his 2 years and 5 months-old Black White-spotted Berkshire Breeding-Sow "Darling," of the large breed; bred by William Hewer, of Sevenhampton.

*William Hatton, of Addingham, Otley: for his 2 years and 1 week-old White Blue-spotted Breeding-Sow "Jenny Lind," of the small breed; bred by Joseph Wilkinson, of Roundhay, Leeds.

*Thomas Crisp, of Chillesford Lodge, Woodbridge: for his 2 years and 4 months-old Black Breeding-Sow "Blackbird," of the small breed; bred by himself.

*William James Sadler, of Purton, Swindon: for his Pen of three 6 months and 4 days-old Berkshire Breeding Sow-Pigs, of the large breed; bred by himself.

*Thomas Crisp, of Chillesford Lodge: for his Pen of three 6 months-old Black Breeding Sow-Pigs, of the small breed; bred by himself.

†Thomas Birkbeck, of Settle: for his 2 years and 10 months-old White Boar "Young Prince," of the large breed; bred by William Hatton, of Addingham, Otley.

†Samuel Munro, of Salford: for his 1 year and 6 months-old White Boar "John," of the large breed; bred by J. Ryley, of Manchester.

†George Mangles, of Givendale: for his 2 years and 3 weeks-old White Boar "Ajax," of the small breed; bred by himself.

†Thomas Crisp, of Chillesford Lodge: for his 6 months and 1 week-old Black Boar (without name), of the small breed; bred by himself.

IMPLEMENTS.

Steam-Cultivator.—The Report of the Judges on the trials made in competition for the Society's undivided Prize of Five Hundred Pounds "for the Steam-Cultivator that shall in the most efficient manner turn over the Soil, and be an economical substitute for the Plough or the Spade," will be found in Mr. Cavendish's General Report on the Exhibition and Trial of Implements in 1856, given in the Journal, vol. xvii., part 2, page 579.

James and Frederick Howard, of Bedford: the Prize of Seven Sovereigns, for their Two-wheeled Iron Plough, marked P P, as the Plough best adapted for general purposes; invented, improved, and manufactured by themselves.

William Ball, of Rothwell, Kettering: the Prize of Four Sovereigns, for his Iron Plough, as the second-best Plough adapted for general purposes; invented, improved, and manufactured by himself.

Edward Hammond Bentall, of Heybridge, Maldon: the Prize of Four Sovereigns, for his Plough marked E H B, as the third-best Plough adapted for general purposes; invented and manufactured by himself.

James and Frederick Howard, of Bedford: the Prize of Five Sovereigns, for their Iron Plough, marked P P P, as the best Plough adapted for heavy land; invented and manufactured by themselves.

William Ball, of Rothwell, Kettering: the Prize of Three Sovereigns, for his Iron Plough, as the second-best Plough adapted for heavy land; invented, improved, and manufactured by himself.

Ransomes and Sims, of Ipswich: the Prize of Two Sovereigns, for their strong Solid-Beam Wrought-Iron Plough, marked Y R S, as the third-best Plough adapted for heavy land; invented, improved, and manufactured by themselves.

James and Frederick Howard, of Bedford: the Prize of Four Sovereigns, for their Two-wheeled Iron Plough with Subsoil Frame, as the best Plough adapted for light land; invented and manufactured by themselves.

Ransomes and Sims, of Ipswich: the Prize of Two Sovereigns, for their light Solid-Beam Iron Plough, marked V R L, as the second-best Plough adapted for light land; invented, improved, and manufactured by themselves.

William Ball, of Rothwell: the Prize of Two Sovereigns, for his Iron Plough, as the third-best Plough adapted for light land; invented, improved, and manufactured by himself.

Edward Hammond Bentall, of Heybridge: the Prize of Two Sovereigns, for his Plough, marked E H B, being a modification of the original Goldhanger Plough, as the fourth-best Plough adapted for light land; invented and manufactured by himself.

James and Frederick Howard, of Bedford: the Prize of Three Sovereigns, for their Improved Ridge or Double-breast Plough, as the best Ridge-Plough; invented and manufactured by themselves.

Ransomes and Sims, of Ipswich: the Prize of Two Sovereigns, for their Trussed-Beam Iron One-way, or Turn-wrest Plough; invented by Henry Lowcock; improved and manufactured by themselves.

William Williams, of Bedford: the Prize of Three Sovereigns, for his set of Four-Beam Diagonal Iron Harrows, as the best Harrows for general purposes; invented by Laurence Taylor, of Cotton-End; improved and manufactured by the Exhibitor.

James and Frederick Howard, of Bedford: the Prize of Three Sovereigns, for their Set of Jointed Iron Harrows, marked 10, as the second-best Harrows for general purposes; invented and manufactured by themselves.

Ransomes and Sims, of Ipswich: the Prize of Two Sovereigns, for their Set of four Heavy East-Anglian Harrows, as the third-best Harrows for general purposes; invented, improved, and manufactured by themselves.

James and Frederick Howard, of Bedford: the Prize of Three Sovereigns, for their Set of Iron Drag-Harrows, marked No. 17, as the best Drag-Harrows for general purposes; invented and manufactured by themselves.

William Williams, of Bedford: the Prize of Two Sovereigns, for his Pair of Drag-Harrows, as the second-best Drag-Harrows for general purposes; invented by Laurence Taylor, of Cotton-End; improved and manufactured by the Exhibitor.

James and Frederick Howard, of Bedford: the Prize of Three Sovereigns, for their Set of Jointed Iron Harrows, marked No. 15, as the best light or Seed-Harrows for general purposes; invented and manufactured by themselves.

William Williams, of Bedford: the Prize of Two Sovereigns, for his Set of Four-Beam Diagonal Iron Harrows, as the second-best light or Seed-Harrows for general purposes; invented by Laurence Taylor, of Cotton-End; improved and manufactured by the Exhibitor.

Edward Hammond Bentall, of Heybridge: the Prize of Two Sovereigns, for his Set of Six Three-Beamed Harrows, as the third-best light or Seed-Harrows for general purposes; invented and manufactured by himself.

Edward Hammond Bentall, of Heybridge: the Prize of Three Sovereigns, for his light Iron-Beam Broadshare Plough, marked L I B B, as the best Cultivator for heavy land; invented and manufactured by himself.

Richard Coleman, of Chelmsford: the Prize of Three Sovereigns, for his Wrought-Iron Drag-Harrow, Cultivator, or Scarifier, as the second-best Cultivator for heavy land; invented, improved, and manufactured by himself.

Ransomes and Sims, of Ipswich: the Prize of Two Sovereigns, for their improved Wrought-Iron Scarifier, Grubber, or Cultivator, No. 7, as the third-best Cultivator for heavy land; invented, improved, and manufactured by themselves.

Richard Coleman, of Chelmsford: the Prize of Three Sovereigns, for his Wrought-Iron Drag-Harrow, Cultivator, or Scarifier, as the best Cultivator for light land; invented, improved, and manufactured by himself.

Edward Hammond Bentall, of Heybridge: the Prize of Three Sovereigns, for his light Iron-Beam Broadshare Plough, marked L I B B, as the second-best Cultivator for light land; invented and manufactured by himself.

Frederick Phillips and James Woods, of Brandon and Stowmarket: the Prize of One Sovereign, for their Finlayson's Self-Cleaning Harrow, as the third-best Cultivator for light land; improved and manufactured by James Woods, of Stowmarket.

Richard Coleman, of Chelmsford: the Prize of Three Sovereigns, for his Wrought-Iron Drag-Harrow, Cultivator, or Scarifier; as the best Scarifier or Parer; invented, improved, and manufactured by himself.

Edward Hammond Bentall, of Heybridge; the Prize of Two Sovereigns, for his Light Iron-Beam Broadshare Plough, marked L I B B, as the second-best Scarifier or Parer; invented and manufactured by himself.

Edward Hammond Bentall, of Heybridge: the Prize of Five Sovereigns, for his Iron-Beam Broadshare and Subsoil Plough, marked B I B, as the best Subsoiler; invented and manufactured by himself.

William Smith, of Little Woolstone, Fenny-Stratford: the Prize of Four Sovereigns, for his Steam or Horse-Power Subsoil-Plough; as the second-best Subsoiler; invented and manufactured by himself.

William Dray and Co., Swan-Lane, London: the Prize of Four Sovereigns, for their Iron Subsoil-Plough, as the third-best Subsoiler; invented, improved, and manufactured by Gray and Co., Uddingston, Glasgow.

James and Frederick Howard, of Bedford: the Prize of Three Sovereigns, for their Two-wheeled Iron Plough, as the fourth-best Subsoiler; invented and manufactured by themselves.

Ransomes and Sims, of Ipswich: the Prize of Three Sovereigns, for their Beauclerc's Trussed-Beam Iron Archimedean Subsoil Plough, with wheels, as the fifth-best Subsoiler; invented by Lord Charles Beauclerc; improved and manufactured by the Exhibitors.

Barrett, Exall, and Andrewes of Reading: the Prize of One Sovereign, for their Subsoil Plough and Pulveriser, as the sixth-best Subsoiler: invented by Richard Read, of London; improved and manufactured by the Exhibitors.

Alfred Crosskill, of Beverley: the Prize of Three Sovereigns, for his Improved Clod-Crusher, as the best Clod-Crusher for heavy land; invented by William Crosskill; improved and manufactured by the Exhibitor.

William Dray and Co., of Swan-Lane: the Prize of Three Sovereigns, for their Compound-Action Clod-Crusher and Roller, as the second-best Clod-Crusher for heavy land; invented and improved by J. Patterson, of Beverley; manufactured by the Exhibitors.

WILLIAM C. CAMBRIDGE, of Bristol: the Prize of Two SOVEREIGNS, for his Roller or Clod-Crusher, as the third-best Clod-Crusher for heavy land: invented, improved, and manufactured by himself.

RANSOMES and SIMS, of Ipswich: the Prize of Two SOVEREIGNS, for their six-feet wide Clod-Crushing Roller, as the fourth-best Clod-Crusher for heavy land; invented by William Crosskill; improved and manufactured by the Exhibitors.

WILLIAM DAY and Co., of Bow-Road, London: the Prize of Two SOVEREIGNS, for their Land-Roller and Clod-Crusher, as the fifth-best Clod-Crusher for heavy land; invented by William Day, manufactured by the Exhibitors.

RANSOMES and SIMS, of Ipswich: the Prize of Two SOVEREIGNS, for their three-cylinder Iron Field-Roller, two feet in diameter, as the best Plain Roller; invented, improved, and manufactured by themselves.

HILL and SMITH, of Brierley Hill, Dudley: the Prize of Two SOVEREIGNS, for their wrought-iron Barley-Roller, seven and a half feet long and two feet in diameter, as the best Plain Roller for light land; invented and manufactured by the Exhibitors.

EDWARD HAMMOND BENTALL, of Heybridge: the Prize of Two SOVEREIGNS, for his Double Land-Roller, with improved heads, joints, and boxes; as the second-best Plain Roller for light land; manufactured by himself.

ALFRED CROSSKILL, of Beverley: for his Clod-Crusher or Serrated Roller, as the best heavy-land Crusher; invented and improved by William Crosskill; manufactured by the Exhibitor.

JOHN WHITEHEAD, of Preston: the Prize of FIVE SOVEREIGNS, for his Drain-Pipe and Tile Machine, as the best Pipe-and-Tile Machine; invented, improved, and manufactured by himself.

THOMAS SCRAGG, of Calveley, Tarporley: the Prize of FOUR SOVEREIGNS, for his Single-Action Tile-Machine, as the second-best Pipe-and-Tile Machine; invented, improved, and manufactured by himself.

HENRY CLAYTON, of Upper Park-Place, Dorset-Square, London: the Prize of FIVE SOVEREIGNS, for his Combined Clay-preparing and Brick-making Machine; invented and manufactured by himself.

BURGESS and KEY, of 95, Newgate-Street, London: the Prize of THREE SOVEREIGNS, for their complete Set of Draining Tools; invented, improved, and manufactured by Francis Parkes, of Birmingham.

ALFRED CROSSKILL, of Beverley: the Prize of TWENTY SOVEREIGNS, for his improved Bell's Reaping-Machine; invented by the Rev. Patrick Bell, of Carmylie, Scotland; improved by William Crosskill, of Beverley; and manufactured by the Exhibitor.

BURGESS and KEY, of 95, Newgate-Street, London: the Prize of FIFTEEN SOVEREIGNS, for their improved MacCormick's Reaping-Machine; invented by C. H. MacCormick, of America; improved and manufactured by themselves.

WILLIAM DRAY and Co., of Swan-Lane, London: the Prize of FIFTEEN SOVEREIGNS, for their Improved Hussey's Reaping-Machine; invented by Obed Hussey, of the United States; improved and manufactured by the Exhibitors.

THOMAS CHAMBERS, JUN., of Colkirk Hall, Fakenham: the Prize of FIVE SOVEREIGNS, specially awarded to him by the Council, on the recommendation of the Judges, "for the newly-invented Implement, the Water-Drop-Drill; invented by himself, and exhibited by Messrs. Garrett."

MEDALS.

RANSOMES and SIMS, of Ipswich: a SILVER MEDAL, for their Cotgreave's Trenching and Subsoil Plough; invented by R. Cotgreave, and manufactured by themselves.

FREDERICK PHILLIPS and JAMES WOODS, of Brandon and Stowmarket: a SILVER MEDAL, for their Poppy and Weed Extirpator, Lever Harrow, and Atmospheric Land-Fertiliser; invented by Frederick Phillips, of Brandon, and manufactured by James Woods, of Stowmarket.

T. E. GRIFFITHS and Co., of Birmingham: a SILVER MEDAL, for their Cheese-making apparatus, intended to effect more readily the separation of the Whey from the Curd; invented by Richard Keevil, of Laycock, Chippenham, and manufactured by the Exhibitors.

ROBERT BOBY, of Bury-St.-Edmunds: a SILVER MEDAL, for his improved Corn-Screen; invented by T. C. Bridgeman, of Bury-St.-Edmund's; improved and manufactured by the Exhibitor.

GEORGE PYE, of Ipswich: a SILVER MEDAL, for flax-fibres illustrating a mode by which the separation of the fibres in the flax-plant is effected, without the necessity of employing the usual processes of retting and scutching; invented by himself and John Watson Burton, of Eye, and manufactured by themselves.

BARRETT, EXALL, and ANDREWES, of Reading: a SILVER MEDAL, for their Endless Band-Saw; invented by W. Exall, of Reading; improved and manufactured by the Exhibitors.

Commendations.

The marks ** signify "VERY HIGHLY COMMENDED;" the mark * signifies "HIGHLY COMMENDED;" the mark † "COMMENDED;" and the mark § "FAVOURABLY MENTIONED."

*WILLIAM BUSBY, of Newton-le-Willows, Bedale: for his Two-Wheeled Plough for general purposes; invented, improved, and manufactured by himself.

†JAMES COMINS, of Southmolton: for his Set of Improved General-Purpose Harrows; invented, improved, and manufactured by himself.

§RICHARD COLEMAN, of Chelmsford: for his heavy extra-width, general-purpose, Expanding Harrow, on the parallel-ruler principle; invented, improved, and manufactured by himself.

*RANSOMES and SIMS, of Ipswich: for their Set of four heavy East-Anglian Drag-Harrows; invented, improved, and manufactured by themselves.

*EDWARD HAMMOND BENTALL, of Heybridge: for his Set of six heavy Two-beamed Drag-Harrows; invented and manufactured by himself.

**HILL and SMITH, of Brierley Hill, Dudley: for their Set of Wrought-Iron Light or Seed Harrows; invented and manufactured by themselves.

†RANSOMES and SIMS, of Ipswich: for their Set of four Three-beam Medium-size East-Anglian Light or Seed Harrows; invented, improved, and manufactured by themselves.

**HUGH CARSON, of Warminster: for his Seven-share Cultivator, or Scarifier, for heavy land; invented, improved, and manufactured by himself.

*ALFRED CROSSKILL, of Beverley: for his Ducie-Drag, or Uley-Cultivator, for heavy land; improved by William Crosskill, and manufactured by the Exhibitor.

*HILL and SMITH, of Brierley Hill, Dudley: for their Wrought-iron Broadshare and Cultivator, for heavy land; invented and manufactured by themselves.

†HILL and SMITH, of Brierley Hill: for their Wrought-iron Skim or Pair-horse Scarifier and Cultivator, as a scarifier for light land; invented, improved, and manufactured by themselves.

†RANSOMES and SIMS, of Ipswich: for their Improved Scotch Grubber, with wheels, as a cultivator for light land; invented, improved, and manufactured by themselves.

§JAMES COMINS, of Southmolton: for his Paring-Plough, as a scarifier for light land; invented, improved, and manufactured by himself.

*ALFRED CROSSKILL, of Beverley: for his Norwegian Harrow; improved by William Crosskill, and manufactured by the Exhibitor.

*JAMES COMINS, of Southmolton: for his Clod-Crusher, Land-Presser, or Pulverizer; invented, improved, and manufactured by himself.

*JAMES FREDERICK UTTING, of Wisbeach: for his Regulating Roller and Clod-Crusher; invented and manufactured by himself.

*HUGH CARSON, of Warminster: for his Cross-cut Wheel-Roller and Clod-Crusher, No. 1; invented, improved, and manufactured by himself.

†BARRETT, EXALL, and ANDREWES, of Reading: for their Universal Wheel-Roller and Clod-Crusher; invented, improved, and manufactured by themselves.

*WILLIAM C. CAMBRIDGE, of Bristol: for his Grooved Roller, or Clod-Crusher; invented, improved, and manufactured by himself.

†RICHARD COLEMAN, of Chelmsford: for his Improved Smooth-jointed Land-Roller, or Clod-Crusher; invented and manufactured by himself.

†WILLIAM LANGFORD FISHER, of Thrapstone: for his Clod-Crushing Field-Roller; invented and improved by Nathaniel Smith, of Thrapstone, and manufactured by the Exhibitor.

*WILLIAM LANGFORD FISHER, of Thrapstone: for his Field-Roller, as a sheep-foot roller; invented and improved by Nathaniel Smith, and manufactured by the Exhibitor.

*RANSOMES and SIMS, of Ipswich: for their Three-cylinder Iron Barley-Roller, 10 inches in diameter, as a light-land roller; invented, improved, and manufactured by themselves.

†HILL and SMITH, of Brierley Hill: for their Circular Iron Vermin-proof Rick-Stand; invented and improved by themselves.

†WILLIAM DRAY and Co., of Swan-Lane: for their Tubular Iron-Gate; invented, improved, and manufactured by themselves.

†HENRY CLAYTON, of Upper Park-Place, Dorset-Square: for his No. 1 Double-action Pipe, Tile, and Tubular Brick Machine; invented, improved, and manufactured by himself.

The marks ** signify "VERY HIGHLY COMMENDED;" the mark * signifies "HIGHLY COMMENDED;" the mark † "COMMENDED;" and the mark § "FAVOURABLY MENTIONED."

JAMES HUDSON,
Secretary.

London, December, 1856.

Essays and Reports.—AWARDS 1854-6.

JOHN HAXTON, of Drumnod, Fifeshire: the Prize of THIRTY SOVEREIGNS, for the best Essay on the Management of Light Lands.

ROBERT VALLENTINE, Farm-manager to the Royal Agricultural College, Cirencester: the Prize of TEN SOVEREIGNS, for the best Essay on the Cultivation of Beans and Peas.

LEWIS HENRY RUEGG, of Sherborne: the Prize of FIFTY SOVEREIGNS, for the best Report on the Farming of Dorsetshire.

CLARE SEWELL READ, of Watlington: the Prize of FIFTY SOVEREIGNS, for the best Report on the Farming of Oxfordshire.

JOHN ALGERNON CLARKE, of Long Sutton: the Prize of FIFTY SOVEREIGNS, for the best Account of Trunk or Arterial Drainage.

EDWARD E. AGATE, of Horsham: the Prize of TEN SOVEREIGNS, for the best Essay on the Autumn Cleaning of Stubbles.

THOMAS GEORGE BELL, LL.D., of Bellevue House, Gateshead: the Prize of FIFTY SOVEREIGNS, for the best Report on the Farming of Durham.

JOHN COLEMAN, of Deene, near Wansford: the Prize of THIRTY SOVEREIGNS, for the best Account of Under-Drainage.

JAMES BUCKMAN, Professor of Botany in the Royal Agricultural College, Cirencester: the Prize of TWENTY SOVEREIGNS, for the best Essay on Agricultural Weeds.

ISAAC SEAMAN (Veterinary Surgeon), Saffron Walden: the Prize of TEN SOVEREIGNS, for the best Essay on Giddiness in Ewes at Lambing.

WILLIAM WALLACE FYFE, of Nottingham: the Prize of TEN SOVEREIGNS, for his Report on the Management and Economical Values of Timber.

CLARE SEWELL READ, of Plumstead, near Norwich: the Prize of FIFTY SOVEREIGNS, for the best Report on the Farming of Buckinghamshire.

HENRY EVERSHED, of Albury, near Guildford: the Prize of FIFTY SOVEREIGNS, for the best Report on the Farming of Warwickshire.

JOHN COLEMAN, of Deene, near Wansford: the Prize of FORTY SOVEREIGNS, for the best Essay on the Causes of Fertility and Barrenness in Soils, so far as observation and science have hitherto enabled them to be ascertained.

ISAAC SEAMAN (Veterinary Surgeon), of Saffron Walden: the Prize of TWENTY SOVEREIGNS, for the best account of the Nature and Treatment of Lameness in Sheep and Lambs.

REV. W. R. BOWDITCH, of St. Andrew's, Wakefield: the Prize of THIRTY SOVEREIGNS, for the best Essay on the Chemical Changes which occur in the Decomposition of Dung.

ROBERT VALLENTINE (Land-Surveyor), of Burcott Farm, Leighton-Buzzard: the Prize of TEN SOVEREIGNS, for the best Essay on the Retention of Moisture in Turnip-Soils.

JAMES BUCKMAN, Professor of Geology in the Royal Agricultural College, Cirencester: the Prize of TWENTY SOVEREIGNS, for the best Essay on the Roots of the Wheat Plant, including a description of their Growth and Development.

ROBERT SMITH, of Emmett's Grange, Southmolton: the Prize of TWENTY SOVEREIGNS, for the best account of the different modes of bringing Moorland into Cultivation.

THOMAS F. JAMIESON, of Ellon, Aberdeenshire: the Prize of FORTY SOVEREIGNS, for the best Essay on the Chemical Results superinduced in Newly-deepened Soil by Atmospheric Action.

PETER LOVE, of Naseby Manor Farm, Northamptonshire: the Prize of TWENTY SOVEREIGNS, for the best Essay on the different Mechanical Modes of Deepening the Staple-Soil, in order to give it the full benefit of Atmospheric Influence.

THOMAS WILLIAM PLAYER ISAAC (Land-Surveyor), of Terrace Walks, Bath: the Prize of TWENTY SOVEREIGNS, for the best Essay and Plans for the Construction of Labourers' Cottages, with special reference to Domestic Convenience.

Essays and Reports.—PRIZES FOR 1857.—All Prizes of the Royal Agricultural Society of England are open to general competition. Competitors will be expected to consider and discuss the heads enumerated.

I. MICROSCOPIC INVESTIGATION.

Fifty Sovereigns will be given for the best Report on the Results of Microscopic Observation applied to the Vegetable Physiology of Agriculture.

It is not thought desirable to confine the observer too strictly to any particular line of research, the only necessary limitation being, that the plants to be examined and reported upon shall be selected from those commonly cultivated; such as the *cereals*, or those usually known under the names of *pulse*, *root*, and *fodder* crops. The structural formation of these plants—their ordinary vital processes —modifications of the above induced by climatic influences or the application of manure—morbid changes of their tissues consequent upon the attacks of insects or disease,—would all prove extensive and interesting fields of inquiry; and it must be left to the writers themselves to select those particular branches of the subject on which they are able to supply the greatest amount of original information.

II. LEVELLING RIDGE AND FURROW IN PASTURES.

Twenty Sovereigns will be given for the best Essay on Levelling Ridge and Furrow Pasture Land after drainage.

Any method recommended must be consistent with the preservation of the old sward, and must be accompanied by a detailed account of the cost of the whole operation.

III. ADMIXTURE OF SOILS.

Twenty Sovereigns will be given for the best Essay on the permanent Amelioration of Soils by admixture with others.

Claying, marling, dry-warping, or any similar operation by which soil of one kind is mixed with land of a different description in sufficient quantity to effect a permanent improvement in its quality, may

properly form the subject of an Essay competing for this prize. Competitors will be expected to state—

1. The mode of carrying on the operation, whether by carting, by moveable railways, or by digging trenches, as practised in the Fen districts.
2. The subsequent mode of cultivation which is found to effect the most complete admixture of the clay, marl, &c., with the land.
3. The nature of the improvement effected; whether land previously too dry becomes observably more retentive of moisture; or, if heavy land, whether superfluous moisture is more rapidly discharged and the difficulty of cultivation thereby lessened.
4. Whether diseases characteristic of certain land, such as deaf ears of corn or finger and toe in turnips, are removed or sensibly diminished.
5. Permanency of benefit.
6. Cost.

IV. DESTRUCTION OF VERMIN.

TEN SOVEREIGNS will be given for the best Report on the Destruction of Vermin infesting the Homestead and Stackyard.

V. ENTERING UPON FARMS.

TWENTY SOVEREIGNS will be given for the best Essay on the comparative Advantages of entering upon Farms in Spring and Autumn, together with Instructions to the young Farmer on his entry at either season.

The instructions to an incoming tenant will be expected to contain—

1. A calendar of farm-work for each month of the year.
2. Stock of different descriptions required per 100 acres.
3. Estimate of food requisite for carrying such stock through the different seasons.
4. Number of horses, carts, and other implements to be provided.
5. Hints for use at the time of entry on the premises; such as methods of calculating the contents of hay-stacks and manure-heaps, mode of dealing with fixtures, &c.

VI. WINTER BEANS.

TEN SOVEREIGNS will be given for the best Essay on the Comparative Advantages of sowing Beans in Spring and Autumn.

As the success of Beans sown in Autumn is materially influenced by the character of the following Winter, competitors will be expected to state the result of more than one year's experience on this subject.

VII. EARLY AND LATE SOWING OF ROOT CROPS.

TEN SOVEREIGNS will be given for the best Essay on the results of early and late sowing of turnips and other root crops.

To avoid mildew, it is found advisable in many parts of the country to *sow late*, even at some sacrifice in weight of crop. State,

1. The practice of different districts in this respect, with any exceptional cases which may be well established.
2. The comparative weight of early and late sown turnips or other root crop. The crops to be compared must have been sown in the same season, on the same description of land, and treated alike in every respect but the time of sowing.
3. The causes of mildew in early sown turnips.

VIII. ANY OTHER AGRICULTURAL SUBJECT.

TEN SOVEREIGNS will be given for the best Essay on any other agricultural subject.

FOR 1858:—

IX. DRILLING CORN AT DIFFERENT WIDTHS.

TEN SOVEREIGNS will be given for the best Report on the result of drilling wheat at different widths with the same quantities of seed, and also with different quantities of seed per acre.

The following set of experiments is recommended, but competitors will be at liberty to adopt any other which will furnish the information required. The trial plots must not contain less than half an acre each:—

Plots 1, 2, 3, drilled at 12 inches from row to row with 4, 6, and 8 pecks of seed per acre, respectively.

Plots 4 and 5, at 10 inches from row to row, with 6 and 8 pecks respectively.

Plots 6 and 7, at 8 inches from row to row, with 6 and 8 pecks respectively.

The Reports or Essays competing for the first eight of these Prizes must be sent to the Secretary of the Society, at 12, *Hanover Square, London, on or before March* 1, 1857, *and in the case of No.* 9, *on or before March* 1, 1858. *Contributors of Papers are requested to retain Copies of their Communications, as the Society cannot be responsible for their return.*

RULES, &c.

RULES OF COMPETITION FOR PRIZE ESSAYS.

1. All information contained in Prize Essays shall be founded on experience or observation, and not on simple reference to books or other sources. Competitors are requested to use foolscap or large letter paper, and not to write on both sides of the leaf.

2. Drawings, specimens, or models, drawn or constructed to a stated scale, shall accompany writings requiring them.

3. All competitors shall enclose their names and addresses in a sealed cover, on which only their motto, the subject of their Essay, and the number of that subject in the Prize List of the Society, shall be written.*

4. The President or Chairman of the Council for the time being shall open the cover on which the motto designating the Essay to which the Prize has been awarded is written, and shall declare the name of the author.

5. The Chairman of the Journal Committee shall alone be empowered to open the motto-paper of any Essay not obtaining the Prize, that he may think likely to be useful for the Society's objects; with a view of consulting the writer confidentially as to his willingness to place such Essay at the disposal of the Journal Committee.

6. The copyright of all Essays gaining Prizes shall belong to the Society, who shall accordingly have the power to publish the whole or any part of such Essays; and the other Essays will be returned on the application of the writers; but the Society do not make themselves responsible for their loss.

7. The Society are not bound to award a prize unless they consider one of the Essays deserving of it.

8. In all reports of experiments the expenses shall be accurately detailed.

9. The imperial weights and measures only are those by which calculations are to be made.

10. No prize shall be given for any Essay which has been already in print.

11. Prizes may be taken in money or plate, at the option of the successful candidate.

12. All Essays must be addressed to the Secretary, at the house of the Society.

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* Competitors are requested to write their motto on the enclosed paper on which their names are written, as well as on the outside of the envelope.

Members' Privileges of Chemical Analysis.

The Council have fixed the following rates of Charge for Analyses to be made by the Consulting Chemist for Members of the Society; who, to avoid all unnecessary correspondence, are particularly requested, when applying to him, to mention the kind of analysis they require, and to quote its number in the subjoined schedule. The charge for analysis, together with the carriage of the specimens, must be paid to him by members at the time of their application.

No. 1.—An opinion of the genuineness of Peruvian guano ..	5s.
„ 2.—An analysis of guano; showing the proportion of moisture, organic matter, sand, phosphate of lime, alkaline salts, and ammonia	10s.
„ 3.—An estimate of the value (relatively to the average of samples in the market) of sulphate and muriate of ammonia, and of the nitrates of potash and soda	10s.
„ 4.—An analysis of superphosphate of lime for soluble phosphates only	10s.
„ 5.—An analysis of superphosphate of lime, showing the proportions of moisture, organic matter, sand, soluble and insoluble phosphates, sulphate of lime, and ammonia	£1.
„ 6.—An analysis (sufficient for the determination of its agricultural value) of any ordinary artificial manure	£1.
„ 7.—Limestone:—the proportion of lime, 7s. 6d.; the proportion of magnesia, 10s.; the proportion of lime and magnesia	15s.
„ 8.—Limestones or marls, including carbonate, phosphate, and sulphate of lime, and magnesia with sand and clay	£1.
„ 9.—Partial analysis of a soil, including determinations of clay, sand, organic matter, and carbonate of lime ..	£1.
„ 10.—Complete analysis of a soil	£3.
„ 11.—An analysis of oil-cake, showing the proportion of moisture, oil, mineral matter, albuminous matter, and woody fibre; as well as of starch, gum, and sugar, in the aggregate	£1.
„ 12.—Analyses of animal products, refuse substances used for manure, &c. .. .. from 10s. to	30s.
„ 13.—Determination of the "hardness" of a sample of water before and after boiling	10s.
„ 14.—Analysis of water of land drainage, and of water used for irrigation	£2.
„ 15.—Determination of nitric acid in a sample of water ..	£1.

N.B.—*The above Scale of Charges is not applicable to Analyses made for Persons commercially engaged in the Manufacture or Sale of Manures.*

The Address of Professor Way, the Consulting Chemist of the Society, is 15, Welbeck Street, Cavendish Square, London, (W), to which all letters and parcels should be directed.

By Order of the Council,

JAMES HUDSON, Secretary.

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JOURNAL OF THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

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LONDON: PRINTED BY W. CLOWES AND SONS, STAMFORD STREET, AND CHARING CROSS.